NOTICE

All drawings located at the end of the document.

RFI/RI FINAL WORK PLAN
FOR OU 3

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

FEBRUARY 28, 1992

REVIEWED FOR CLASSIFICATION/UCNI
By K. L. Dittmer (UNC)
Date 2/28/92

DEN/FLATS15/027.51

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LIST OF ACRONYMS

The following is a list of acronyms used throughout this work plan.

ac	acre
ACL	Alternative Concentration Limit
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
ARAR	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
BLUE	Best linear unbiased estimator
BNA	Base-neutral acid extractable organics
Bq/g	Becquerel per gram
Bq/l	Becquerel per liter
BRA	Baseline Risk Assessment Plan
BRAP	Baseline Risk Assessment Plan
CAD	Corrective Action Decision
CCEI	Colorado Committee on Environmental Information
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CDOW	Colorado Division of Wildlife
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CLP	Contract Laboratory Program
cm	centimeters
CMP	corrugated metal pipe
CMS	corrective measures study
COCs	Contaminants of Concern
CPOM	coarse particulate organic matter
CWQCC	Colorado Water Quality Control Commission
CRP	community relations plan
CSU	Colorado State University
CV	coefficient of variation
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyl trichloroethane
DOE	Department of Energy
DQO	data quality objective
DRCOG	Denver Regional Council of Governments
DWR	Colorado Division of Water Resources

EE	environmental evaluation
EEP	Environmental Evaluation Plan
EEWP	Environmental Evaluation Work Plan
Eh	oxidation-reduction capacity
EIS	Environmental Impact Statement
EMAD	Environment Monitoring and Assessment Division of RFP
EPA	Environmental Protection Agency
ER	environmental restoration
ERDA	Energy Research and Development Administration
FIDLER	Field Instrument for Detection of Low Energy Radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FSP	field sampling plan
ft	foot/feet
GAC	granular activated carbon
Gbq	gigabecquerel
GC	gas chromatography
GPR	ground penetrating radar
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HEAST	Health Effects Assessment Summary Tables
HSP	Health and Safety Plan
HSU	Hydrostratigraphic unit
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
ICRP	International Commission on Radiological Protection
IM/IRA	Interim Measures/Interim Remedial Action
in	inches
in/hr	inch(es) per hour
IRIS	Integrated Risk Information System
K_d	Distribution coefficient
km	kilometer
La	Lectacne
LANL	Los Alamos National Laboratory
LD_{50}	lethal dose to 50 percent of the population
LLNL	Lawrence Livermore National Laboratory
LOEL	Lowest Observable Effect Level
MATC	Maximum Allowable Tissue Concentration
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mCi/km^2	microcurie per square kilometer
mg/kg/day	milligrams of chemical per kilogram of body weight per day
mi	mile
ml	milliliter
µm	micrometer
mm	millimeter

MSL	mean sea level
NAAQSs	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOEL	No Observable Effect Level
NPDES	National Pollution Discharge Elimination System
NRDA	Natural Resource Damage Assessment
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
pCi/g	picocuries per gram
pCi/kg/day	picocuries of radionuclide per kilogram of body weight per day
pCi/l	picocuries per liter
pH	hydrogen in concentration
PID	photoionization detector
PQL	practical quantification limits
Pu	Plutonium
PuO_2	Plutonium Dioxide
$Pu(OH)_4$	plutonium hydroxide
PNL	(Battelle) Pacific Northwest Laboratory
QAA	Quality Assurance Addendum
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAS	Routine Analytical Services
RBP	Rapid Bioassessment Protocols
RCRA	Resource Conservation and Recovery Act
Rd	Retardation factors
RFDs	Reference doses
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA facility investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RMAAP	Radioactive Ambient Air Program
RMaxE	Reasonable Maximum Exposure
RME	Reasonable Maximum Exposure
RMinE	Reasonable Minimum Exposure
ROD	Record of Decision
SAS	Special Analytical Services
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SB	soil boring
SCS	Soil Conservation Service (U.S. Department of Agriculture)
SID	South Interceptor Ditch

SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum
SPHEM	Superfund Public Health Evaluation Manual
TAL	target analyte list
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TDS	total dissolved solids
TIC	tentatively identified compounds
TOC	total organic carbon
TSCA	Toxicide Substances Control Act
TVS	Table Value Standards (hardness dependent)
uCi/m^2	microcurie per square meter
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	ultraviolet
VOA	volatile organic analysis
VOC	volatile organic compound
WQC	Water Quality Criteria
WQCC	Water Quality Control Commission

EXECUTIVE SUMMARY

This document presents the work plan for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) of the Operable Unit Number 3 (OU 3) at the Rocky Flats Plant (RFP), Jefferson County, Colorado. This work plan includes a field sampling plan (FSP) that presents the investigation planned to evaluate the presence or absence of contamination at Individual Hazardous Substance Sites (IHSSs) within OU 3. The FSP presented in this work plan is based on the requirements of the Interagency Agreement (IAG) among the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH). Four IHSSs, as identified in the IAG, are included in OU 3. They are IHSS 199 (contamination of the Land's Surface), IHSS 200 (Great Western Reservoir), IHSS 201 (Standley Lake), and IHSS 202 (Mower Reservoir).

Section 1.0 of this work plan presents introductory information and a general characterization of the region and plant site. In addition, the regional geology and hydrology at Rocky Flats are discussed. **Section 2.0** presents descriptions of the site physical characteristics, histories and previous investigations, available information concerning the nature and extent of contamination, and conceptual models for each of the 4 IHSSs based on existing data. This initial characterization forms the basis for establishing data needs, data quality objectives (DQOs), and developing an FSP for each IHSS. **Section 3.0** presents applicable or relevant and appropriate requirements (ARARs) developed for OU 3. **Section 4.0** outlines RFI/RI tasks to be performed. **Section 5.0** establishes data needs and DQOs considering site characteristics and conceptual models of each IHSS in OU 3. A FSP, based on the requirements of the IAG, is presented in **Section 6.0** to satisfy the data needs and DQOs identified in Section 5.0. The Human Health Risk Assessment Plan and Environmental Evaluation Plan and Sampling Plan are presented in **Sections 7.0** and **8.0**, respectively. **Section 9.0** presents the general schedule for the RFI/RI tasks. A Quality Assurance Addendum and Standard Operating

Procedure Addenda (SOPA) are presented in **Sections 10.0 and 11.0**, respectively. A list of references is presented in **Section 12.0.**

The IAG also required preparation of separate historical information summaries and preliminary human health risk assessments for IHSS 199 and IHSSs 200 to 202. The Final Past Remedy Report Operable Unit No. 3–IHSS 199 (DOE, 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 IHSS 200 to 202 (DOE, 1991b) were approved by EPA and CDH in May 1991 and June 1991, respectively. These reports describe OU 3 site physical and chemical characteristics, provide synopses of environmental investigations conducted to date at OU 3, formulate conceptual models for contaminant fate and mobility, provide preliminary human health risk assessments based upon existing data, and identify additional data needed to support a detailed site characterization and the Baseline Risk Assessment (BRA) (Human Health Risk Assessment and the Environmental Evaluation) for OU 3. The information in these OU 3 reports was used to support the Site Characterization (Section 2.0) and development of DQOs (Section 5.0) in this work plan.

DQOs have been developed for this RFI/RI investigation. DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI. The DQO process is divided into three stages. Through application of the DQO process, site-specific RFI/RI goals are established and data needs are identified for achieving these goals.

The following objectives of the OU 3 RFI/RI have been identified:

- Characterize the physical features and ecological characteristics
- Characterize the nature and extent of contamination at each IHSS in each media that is a potential exposure pathway
- Collect data to support the Human Health Risk Assessment

- Collect data to support the Environmental Evaluation

Within these broad objectives, site-specific data needs have been identified based on the conceptual models and preliminary identification of contaminant-specific ARARs for OU 3 and data needs for the BRA. The FSP is briefly summarized below.

SOIL

Surface soil samples will be collected within an area that extends approximately 3 miles (mi) east of Indiana Street and over 4 mi north-south along the entire eastern boundary of the plant utilizing a grid with 1,000 meter (m) spacing. The grid also extends to the north and south of the RFP buffer zone. Vertical profile soil samples will also be collected in undisturbed areas. Soil samples will be analyzed for Pu, Am, U, total organic carbon (TOC), bulk density, and grain size.

SEDIMENT

Sediment samples will be collected in the OU 3 drainages and in the three reservoirs. Sediment samples will also be collected along the shores of each of the reservoirs. Sediment samples will be analyzed for Pu, Am, U, target compound list (TCL) volatiles in Mower Reservoir, and associated drainage, target analyte list (TAL) metals, TOC, bulk density, and grain size.

SURFACE WATER

Surface water samples will be collected in the OU 3 drainages and in the three reservoirs. The samples will be analyzed for Pu, AM, U, gross alpha, gross beta, TAL metals, cations/anions, dissolved oxygen, pH, and specific conductance. The cation/anion analyses will be used in the aquatic evaluations. TCL volatiles will also be analyzed in Mower Reservoir for site characterization.

GROUNDWATER

Two groundwater monitoring wells will be installed near Great Western Reservoir and two groundwater monitoring wells will be installed near Standley Lake. The groundwater samples will be analyzed for Pu, AM, U, gross alpha, gross beta, and cation/anions for site characterization.

AIR

Air samples will be collected using a wind tunnel in low-lying areas along the shores of Great Western Reservoir and Standley Lake, and in a vegetated area of OU 3. Two continuous ultra hi-volume air samplers will also be installed near Standley Lake. The air samples will be analyzed for Pu, Am, and U.

TERRESTRIAL BIOTA

Qualitative and quantitative field surveys will be conducted. Vegetation, wildlife/habitat types, and wetlands/riparian zones will be identified as part of the qualitative surveys. Vegetation (above-ground biomass), wetlands vegetation, and small mammals will be sampled as part of the quantitative surveys and analyzed for Pu, Am, and U.

AQUATIC BIOTA

Benthic macroinvertebrates, periphyton, and fish will be sampled and analyzed for Pu, Am, U, and TAL metals.

Data collected during the OU 3 RFI/RI will be incorporated into the existing Rocky Flats Environmental Database System (RFEDS) database. These data will be used to better define site characteristics, source characteristics, and the nature and extent of contamination; and to support the BRA (Human Health and Environmental Evaluation). An RFI/RI report will be prepared summarizing the data obtained during the field investigation program and containing the BRA.

1.0 INTRODUCTION

This document presents the work plan for conducting the Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) of Operable Unit No. 3 (OU 3) at the U.S. Department of Energy (DOE) Rocky Flats Plant (RFP). Existing information is summarized to characterize OU 3, and a field sampling program is developed to assess the nature and extent of contamination at the four Individual Hazardous Substance Sites (IHSSs, or Sites), which comprise OU 3: IHSS 199 (Contamination of the Land's Surface), IHSS 200 (Great Western Reservoir), IHSS 201 (Standley Lake), and IHSS 202 (Mower Reservoir). The OU 3 RFI/RI is part of an ongoing program of site characterizations, remedial investigations, feasibility studies, and remedial actions at the RFP.

1.1 DOE ENVIRONMENTAL RESTORATION PROGRAM

Investigations and remediation of RFP OUs are being conducted under the DOE Environmental Restoration (ER) Program. The ER Program is designed to investigate and, if necessary, remediate contaminated sites at DOE facilities. The program involves five major activities:

- **Activity 1—Installation Assessments** including preliminary assessments and site inspections to assess potential environmental concerns

- **Activity 2—Remedial Investigations** including the development and implementation of field sampling programs to determine the magnitude and extent of contamination at specific sites, the evaluation of contaminant fate and mobility in the environment, and the performance of Baseline Risk Assessments (BRA)

- **Activity 3—Feasibility Studies** to evaluate remedial alternatives and develop remedial action plans, as necessary, to remediate sites identified during Activity 2

- **Activity 4—Remedial Designs/Remedial Actions** including design and implementation of site-specific remedial actions selected on the basis of Activity 3 Feasibility Studies

- **Activity 5—Compliance and Verification** to monitor and assess the performance of remedial actions implemented under Activity 4 and to document their efficacy.

Activity 1 has been completed for the RFP (DOE, 1986). The OU 3 RFI/RI Work Plan falls under Activity 2.

1.2 WORK PLAN SCOPE

The scope of the OU 3 RFI/RI is derived from the Interagency Agreement (IAG) between the U.S. Environmental Protection Agency (EPA), the Colorado Department of Health (CDH), and the DOE (EPA, 1991). The IAG describes the general response processes for IHSSs at the RFP. These sites are grouped into 16 OUs, one of which is OU 3. The RFI/RI and all response activities performed by the DOE under the IAG are to be consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the RCRA, the National Contingency Plan (NCP), and the Colorado Hazardous Waste Act (CHWA). Pertinent EPA guidance documents include the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988) and Interim Final RCRA Facility Investigation (RFI) Guidance (EPA, 1989a). RFP OUs are classified under the IAG as:

1. State-lead OUs that CDH will address primarily under RCRA and CHWA (but also will address CERCLA requirements as appropriate)

2. EPA-lead OUs that EPA will address primarily under CERCLA (but also will address RCRA and CHWA requirements as appropriate)

3. Joint EPA-CDH lead OUs, which will incorporate elements of RCRA, CERCLA, and CHWA.

OU 3 has been designated an EPA-lead OU.

Section VI of the IAG Statement of Work (Attachment 2 of the IAG) spells out objectives for RFI/RI work plans at the RFP. The primary objective of the OU 3 RFI/RI is to conduct a detailed site characterization which meets the following goals:

- Define OU 3 site physical characteristics
- Define sources of contamination
- Describe the nature and extent of contamination
- Describe contaminant fate and transport
- Provide data to support a BRA to establish the baseline risk for the OU and to evaluate the need for Interim Measures/Interim Remedial Actions (IM/IRAs).

This work plan is organized into the following sections:

- **Section 1.0** provides introductory information and a general characterization of the RFP and the surrounding region.
- **Section 2.0** presents a characterization of OU 3 site conditions, previous environmental investigations, available information regarding the nature and extent of contamination, and conceptual models for the soils (IHSS 199) and the reservoirs

(IHSSs 200, 201, and 202, including fate and transport of contaminants for each pathway).

- **Section 3.0** identifies potential Applicable or Relevant and Appropriate Requirements (ARARs) for OU 3.

- **Section 4.0** identifies specific RFI/RI tasks to be performed.

- **Section 5.0** establishes data needs and Data Quality Objectives (DQOs) based upon the site characterization information presented in Section 2.0.

- **Section 6.0** presents a Field Sampling Plan (FSP) to satisfy the data needs and DQOs identified in Section 5.0.

- **Section 7.0** presents the Human Health Risk Assessment Plan for OU 3.

- **Section 8.0** presents the Environmental Evaluation Work Plan (EEWP) and Sampling Plan for OU 3.

- **Section 9.0** provides a schedule for completion of the RFI/RI tasks identified in Section 4.0 in accordance with the scheduling requirements of the IAG.

- **Section 10.0** provides a Quality Assurance Addendum (QAA) for quality assurance issues specifically related to the OU 3 RFI/RI.

- **Section 11.0** provides Standard Operating Procedure Addenda (SOPA) for procedures specific to the OU 3 RFI/RI.

- **Section 12.0** provides references.

- **Appendix A** presents the Conceptual Model Pathways.

- **Appendix B** is a summary of results from sampling logs along Indiana Street.

- **Appendix C** presents power curves based on historical data.

- **Appendix D** describes the design of optimal strategy for sampling plutonium (Pu) and americium (Am) in soils of OU3.

- **Appendix E** presents the plutonium 238 and 239/240 testing of the surface soil on the Conda, Spicer, and McKay gravel lease properties on the Rocky Flats West Buffer Zone.

Included in the IAG required actions for OU 3 are the preparation of historical information summaries and preliminary human health risk assessments for offsite soils (IHSS 199) and offsite reservoirs (IHSSs 200, 201, and 202). The two reports have received approval by EPA and CDH (DOE, 1991a; DOE, 1991b). These reports describe OU 3 site physical and chemical characteristics, provide synopses of environmental investigations conducted to date at OU 3, formulate conceptual models for contaminant fate and mobility, provide preliminary human health risk assessments based upon existing data, and identify data gaps that must be filled in order to support a detailed site characterization and BRA under the OU 3 RFI/RI. The information in these OU 3 reports was used to support the Site Characterization (Section 2.0) and development of DQOs (Section 5.0) in this work plan.

1.3 REGIONAL AND RFP SITE BACKGROUND INFORMATION

The following subsections provide general information on the RFP and the surrounding region, including RFP history, regional land use and population data, and site conditions.

1.3.1 RFP Mission and History

The RFP is part of a nationwide nuclear weapons complex owned by DOE. The facility is contractor-operated by EG&G Rocky Flats, Inc. (EG&G) as a nuclear weapons research, development, and production complex. The RFP fabricates components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Support activities include chemical recovery and purification of recyclable transuranic radionuclides, and research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics (DOE, 1988).

Construction of the RFP began in 1951, and the first production activities commenced the following year. Operation of the RFP fell under the administration of the U.S. Atomic Energy Commission (AEC) from 1951 until the AEC was dissolved in January 1975. Responsibility for the plant was then transferred to the Energy Research and Development Administration (ERDA), which was succeeded in 1977 by DOE. Dow Chemical USA was the prime operating contractor of the facility from 1951 until 1975. Rockwell International succeeded Dow Chemical USA from 1975 through 1989, when EG&G assumed RFP operations.

1.3.2 Physical Setting

The RFP is situated on 6,550 acres (ac) (2,650 hectares [ha]), of federal property in Jefferson County, Colorado, 16 miles (mi) (26 kilometers [km]) northwest of downtown Denver. The 385 ac (156 ha) main production facility of the RFP, within the plant's controlled area, is surrounded by a 6,150 ac (2,491 ha) buffer zone that delineates the RFP boundary (Figure 1-1).

1.3.2.1 Climatology

The RFP area has a semiarid climate typical of the Rocky Mountain region. Local climatology is controlled in large part by the nearby slopes of the Front Range.

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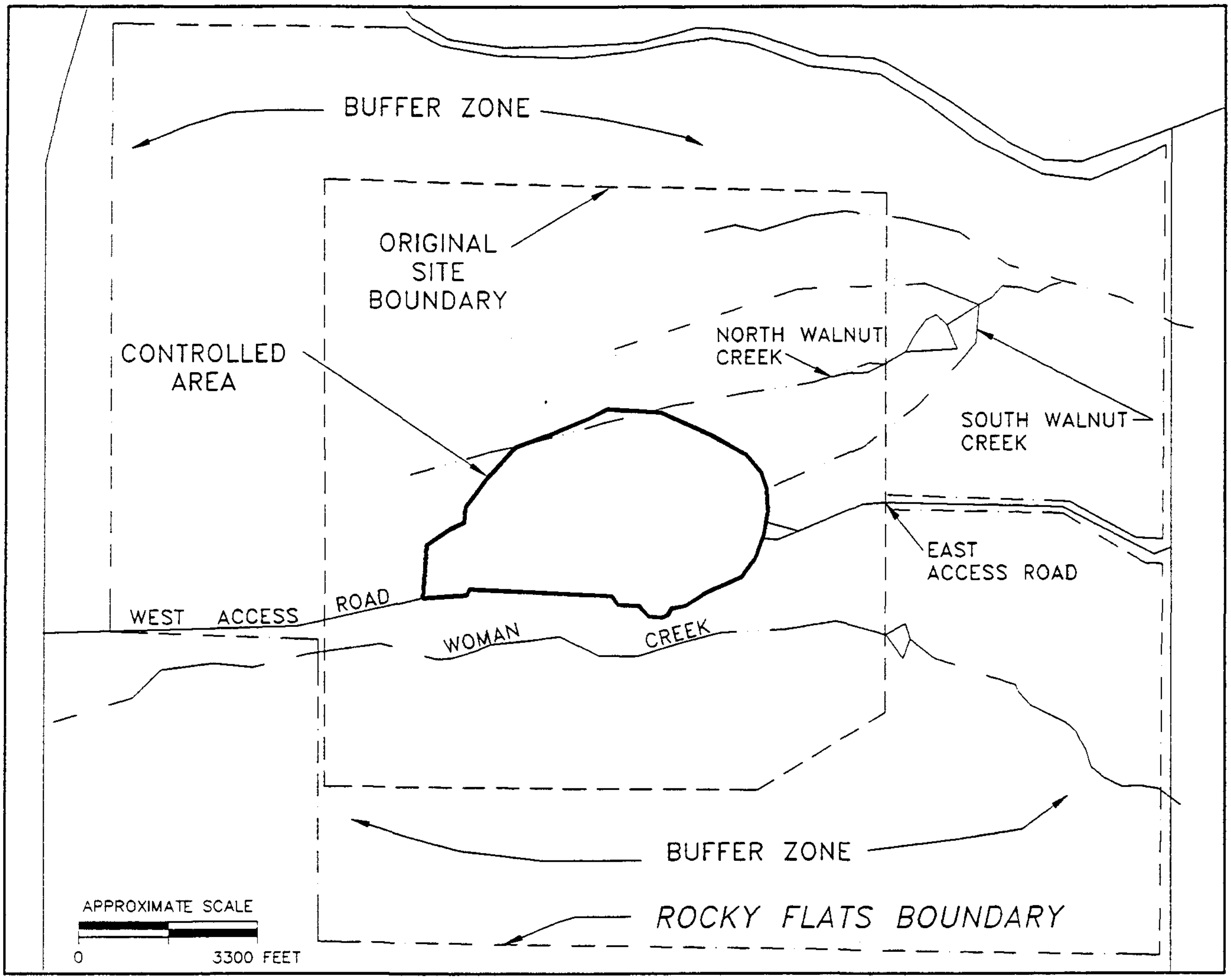

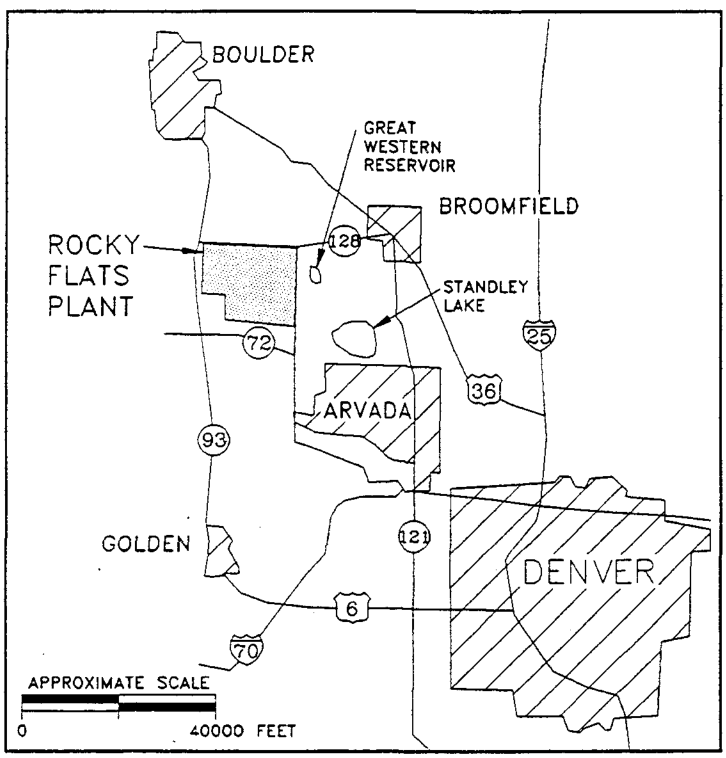

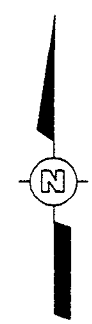

Figure 1-1
ROCKY FLATS LOCATION MAP

ADAPTED FROM: FIG. 1-1, E.G. & G. DRAFT GEOLOGIC CHARACTERIZATION REPORT, JAN. 3, 1990.

Winds in the area are variable in direction but are predominantly from the west (westerly). Stronger winds occur during the winter months, and the area occasionally experiences gusts in excess of 100 miles (mi) per hour. Area temperatures are moderate; extreme hot or cold weather typically is of short duration. Average summer temperatures range from 55 to 85 degrees Fahrenheit (°F), or 13 to 29 degrees Celsius (°C), while winter temperatures typically range from 20° to 45°F (-6° to 7°C) (DOE, 1980).

Average total precipitation for the RFP area is approximately 15 inches per year (in/yr) (38 cm/yr), with 40 percent of this falling during the spring. Snowfall averages 85 in/yr (216 cm/yr) (DOE, 1980). Rainfall intensity and duration vary widely. During a 3-year hydrological study of the RFP between 1972 and 1975, rainfall intensities varied from <0.1 inches per hour (in/hr) (<0.25 centimeters per hour [cm/hr]) to approximately 0.5 in/hr (1.25 cm/hr) (USGS, 1976). Frontal storms with long, low-intensity rainfall durations occur in the autumn and early spring, while short, intense cloudbursts are frequent in the late spring and summer months.

1.3.2.2 Physiography

The RFP is situated at an elevation of approximately 6,000 feet (ft), or 1,830 meters (m), above mean sea level, on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman, 1931). The site is located where the Colorado Piedmont is terminated abruptly by the Front Range section of the southern Rocky Mountains. The Front Range rises to elevations of 12,000 to 14,000 ft (3,660 to 4,270 m) to the west of the RFP site.

The Colorado Piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains. It is underlain by gently dipping sedimentary rocks, which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front. The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of several hundred feet (approximately 100 m). This relief is attributed both to resistant bedrock units that rise above the landscape and to incised stream drainages. Major stream valleys run predominantly from west to east in the area. Numerous local valleys from minor tributaries also exist (DOE, 1980).

In the RFP area, a series of Quaternary pediments have been deposited across the gently rolling piedmont surface and incised by several minor drainages. The RFP is located on a relatively flat surface formed by one such pediment. The pediment has been eroded by creeks on the north and south to form a terrace that ranges in height from 50 to 150 ft (15 to 46 m). The grade of the dissected pediment surface ranges from 0.7 percent at the RFP to approximately 2 percent just east of the plant (DOE, 1990).

1.3.3 Geologic Setting

The RFP is located on the northwestern flank of the Denver Basin, an asymmetric syncline that formed during the late Cretaceous Laramide Orogeny. The western limb of the basin dips steeply to the east, while the eastern limb dips gently to the west. The axis of the basin is located approximately 10 mi (16 km) east of the RFP.

1.3.3.1 Bedrock

The Cretaceous-age Arapahoe Formation underlies surficial deposits in the RFP area. The maximum thickness of the formation in the area is approximately 270 ft (82 m). The Arapahoe Formation consists of fluvial claystones with interbedded, discontinuous sandstone and siltstone lenses, and channels. The lower half of the formation contains more sandstones than the upper half. Bedrock dips beneath the RFP are approximately 2 degrees to the east (EG&G, 1990a).

A major erosional surface developed in the RFP area during late Tertiary time, completely removing two formations overlying the Arapahoe Formation and eroding into the Arapahoe. Weathering penetrates the Arapahoe Formation beneath surficial deposits to a depth of 10 to 40 ft (3 to 12 m) (DOE, 1990). Drainages eroded into the formation were infilled by later surficial deposits. The top of the bedrock surface beneath the surficial deposits generally parallels the ground surface topography, with bedrock lows along existing drainageways and creeks (EG&G, 1990a).

The Arapahoe Formation is directly underlain by the Laramie Formation, a fluvial sequence of sandstones, siltstones, claystones, and coal. The upper Laramie Formation, which subcrops immediately west of the RFP, consists of some 750 ft (230 m) of claystone. Underlying the Laramie Formation are up to 10,000 ft (3,280 m) of Paleozoic and Mesozoic sedimentary rocks. To the west of the RFP, resistant sedimentary units form ridges where they are upturned along the flank of the Front Range.

1.3.3.2 Surficial Deposits

Surficial deposits in the RFP area consist of unconsolidated Quaternary-age units, which unconformably overlie the Arapahoe Formation and other subcropping bedrock units. The RFP is located on a terrace capped by Rocky Flats Alluvium, which is the oldest and topographically highest of the surficial deposits in the area. The Rocky Flats Alluvium is a series of laterally coalescing fans deposited by streams. Bedding is uncommon. The unit consists of sand, clay, silt, gravel, cobbles, and occasional boulders, and is weakly to moderately cemented with caliche (calcium carbonate) in some areas.

Younger alluvial deposits existing topographically below the Rocky Flats Alluvium include the Verdos and Slocum Alluviums. These deposits consist largely of drainage infilling with reworked Rocky Flats Alluvium. In addition, active deposition of valley fill alluvium is occurring within existing drainages in the RFP area (DOE, 1990).

1.3.4 Hydrology

The following sections contain general information about the surface water and groundwater systems in the RFP area.

1.3.4.1 Surface Water

Several ephemeral streams flow through the RFP area. Three of these streams (North Walnut Creek, South Walnut Creek, and Woman Creek) originate within the RFP boundary and flow generally eastward from the plant site. The Walnut Creek and Woman Creek drainages within the boundary of the RFP are being investigated under the IAG as OU 5 and OU 6, respectively. A fourth ephemeral stream, Rock Creek, originates in the Buffer Zone northwest of the main production facility and flows northeast from the RFP (Figure 1-2). Other surface water features in the vicinity of the plant include a complex network of manmade diversions and impoundments. RFP surface water features are shown in Figures 1-2 and 1-3. Flow into and within these features results from direct surface runoff, baseflow from groundwater, and diversions and wastewater from human-related activities. A sitewide study of the hydrology of the RFP determined that surface runoff in the Woman Creek basin averages only 1.4 percent of rainfall, indicating either a high soil infiltration rate or high surface retention capacity. This figure was based on records for long-duration, low-intensity precipitation; runoff may be much higher for a short-duration, high-intensity event (USGS, 1976).

1.3.4.2 Groundwater

Two groundwater systems exist in the RFP area: an unconfined system which is present in saturated surficial deposits (the upper hydrostratigraphic unit) in many areas of the RFP, and a confined system in claystones and sandstones of the underlying Arapahoe Formation (the lower hydrostratigraphic unit) (USGS, 1976). The shallow unconfined system is recharged by infiltration from incident precipitation and from surface and baseflow water (such as drainages and reservoirs). Groundwater flow is generally to the east and towards drainages. Groundwater locally discharges as seeps or springs in drainages, especially where the surficial deposit/bedrock contact is exposed. Large water table fluctuations may occur in the shallow system in response to seasonal variations in recharge and discharge, with the highest water levels generally occurring during the months of May and June and the lowest water levels generally occurring in January and February. As a result of these fluctuations, the lateral and vertical extent of saturated surficial deposits varies seasonally. Several past studies have measured hydraulic conductivity in the upper and lower hydrostratigraphic units using drawdown-recovery tests, pump tests, packer testing and slug testing on selected wells (USGS, 1976; Hydro-Search, 1985; Rockwell, 1988a). Recent work has estimated hydraulic conductivities for RFP geologic units vary widely (EG&G, 1991, Under Revision). This is because of the heterogeneity of the geologic units. Efforts are ongoing to define hydraulic conductivities (EG&G, 1991, Under Revision).

Confined groundwater in the lower hydrostratigraphic unit exists primarily in lenticular sandstone bodies within claystone. Groundwater flow in the upper hydrostratigraphic unit occurs in the unconsolidated Quaternary surficial deposits and the shallow sandstone within the bedrock. Recharge to this unit consists of infiltration from streams and precipitation. The lower hydrostratigraphic unit is found in the deeper bedrock sandstones, which exhibit confined conditions. Recharge to this unit occur primarily from baseflow and leakage from the overlying claystone. Groundwater in the lower hydrostratigraphic unit flows east towards a regional discharge area along the South Platte River, some 20 mi (32 km) east of the RFP. Calculated horizontal linear flow velocities for the system average 0.1 ft/day (0.03 m/day) in the sandstones and approximately $9x10^{-4}$ ft/day ($2.7x10^{-4}$ m/day) in the claystone (USGS, 1976; Hydro-Search, 1985).

1.3.5 Ecology

The ecosystems in the RFP area and surrounding region are typical for foothill, ravine, and high plains portion of Colorado and include aquatic and terrestrial ecosystems. The aquatic ecosystems include perennial and intermittent streams, and manmade ditches, canals, ponds, and reservoirs. Terrestrial ecosystems occur on all drainages, slopes, and uplands. Many of the natural ecosystems have been converted to other uses, such as commercial and residential development, agriculture and rangeland grazing, and water control and storage. The remaining ecosystems have experienced some effects from surrounding land use and few or no pristine areas exist in the vicinity of the RFP. However, some areas within the RFP buffer zone have not been disturbed for 20 or more years.

The principal components of the aquatic ecosystems are the periphyton, phytoplankton, benthic macroinvertebrates, amphibians, and fish. The type of aquatic communities and diversity of species in each of these components is dependent on the type of substrate, water characteristics (such as depth and flow regime, water quality, creek or pond morphology), water management practices, and season. Fish species are most abundant in the larger ponds and reservoirs, and are mostly absent in the intermittent streams.

Vegetation in the terrestrial ecosystems is representative of high plains and foothill ravine regions, and includes native grassland with tall and short prairie grass species and associated shrubs and forbs. Riparian and wetland vegetation occurs along drainages and around springs and seeps. Portions of the grasslands and riparian vegetation have been converted to other land uses, and the grasslands have been and are being grazed as rangeland.

Flora in the RFP area are representative of lower mountainous and foothill ravine regions and include species of tall and short prairie grass. Riparian vegetation occurs along drainages and in wetlands. None of the vegetative species present at the RFP are reported to be on the endangered species list (EG&G, 1991a). Many of the disturbed areas of the RFP have been revegetated since establishment of the plant using native or introduced species.

The fauna inhabiting the RFP area are typical of western prairie regions. The most common large mammal is the mule deer. There are a number of small carnivores, such as the coyote, red fox, striped skunk, and long-tailed weasel. Numerous small herbivores are found throughout the area, including the prairie dog, pocket gopher, white-tailed jackrabbit, and the meadow vole. Birds common to the area include the western meadowlark, horned lark, mourning dove, and vesper sparrow. Killdeer, red-winged blackbirds, and a variety of ducks are seen near ponds. Mallards and other ducks frequently nest and breed on RFP ponds. Birds of prey in the area include the marsh hawk, red-tailed hawk, ferruginous hawk, rough-legged hawk, and great horned owl. Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers are also observed. The eastern short-horned lizard has been reported on the RFP, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around ponds in the area (DOE, 1980).

The U.S. Fish and Wildlife Service (USFWS) has indicated that the two endangered species of interest in the RFP are the bald eagle and the black-footed ferret (Rockwell, 1988c). Prairie dog towns provide the food source and habitat for ferrets.

1.3.6 Demographics

The population, economics, and land use of the areas surrounding the RFP are described in a 1989 Rocky Flats vicinity demographics report by DOE (DOE, 1991d). This report divides general use of areas within zero to 10 mi (zero to 16 km) of the RFP into residential, commercial, industrial, parks and open spaces, agricultural and vacant, and institutional classifications, and considers current and future land use near the plant.

1.3.6.1 Current Population and Land Use

The majority of residential use within 5 mi (8 km) of the RFP is located immediately north and southwest of Standley Lake (IHSS 201). Single-family dwellings are located in unincorporated areas immediately east and south of the RFP. Figure 1-4 shows the 1989 population distribution within areas up to 5 mi from the RFP. Commercial development is concentrated near the residential developments north and southwest of Standley Lake, and around the Jefferson County Airport approximately 3 mi (4.8 km) northeast of the RFP. Industrial land use within 5 mi (8 km) of the plant is limited to quarrying and mining operations. Open Space lands are located northeast of the RFP near the City of Broomfield, and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada. Standley Lake is surrounded by Standley Lake Park. Irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of the RFP near the cities of Broomfield, Lafayette, and Louisville, north of the RFP near Louisville and Boulder, and in scattered parcels adjacent to the eastern boundary of the plant. Several horse operations and small hay fields are located south of the RFP. The demographics report characterizes much of the vacant land adjacent to the RFP and the reservoirs as rangeland (DOE, 1991d).

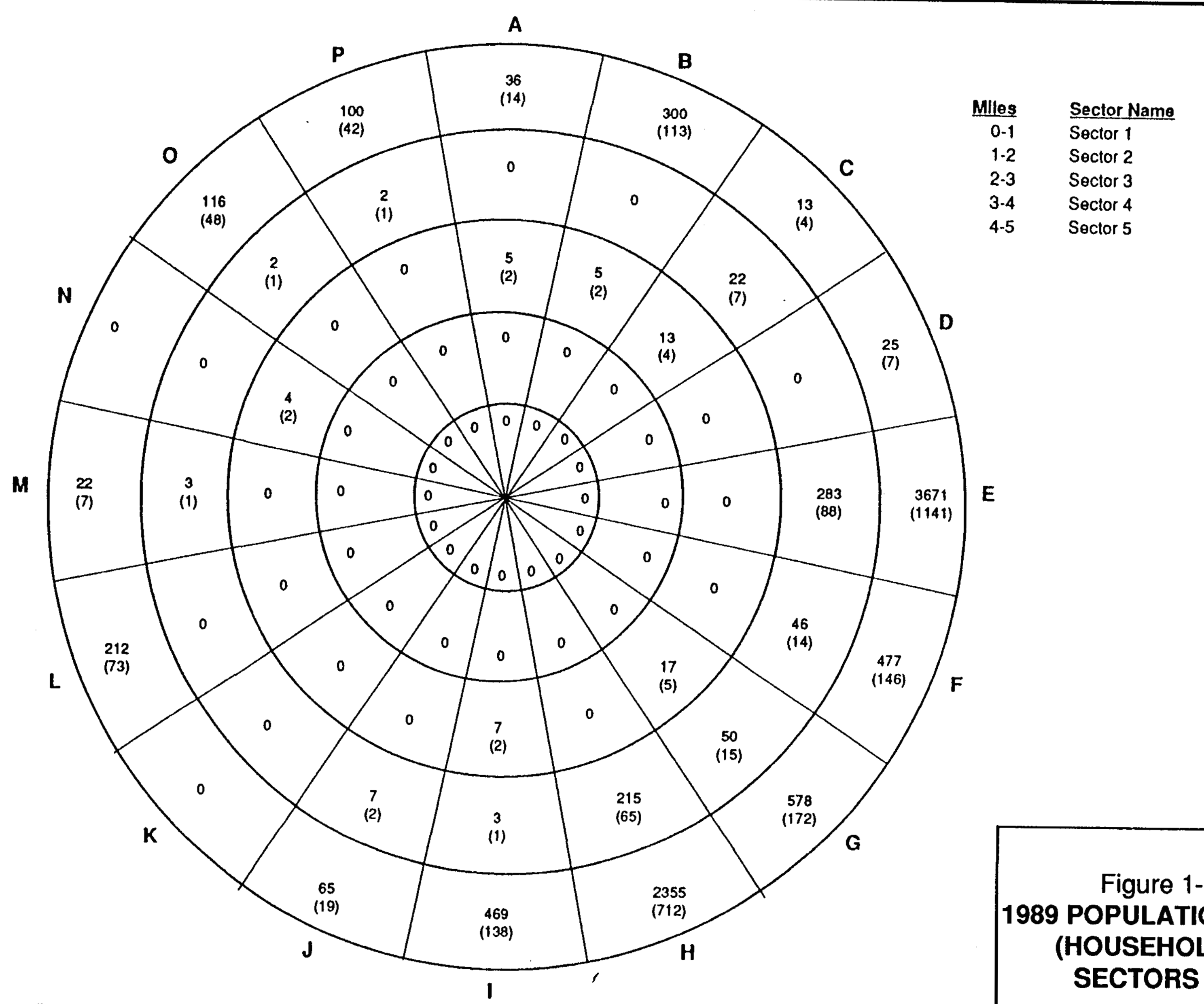

Figure 1-4
1989 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

SOURCE: DOE, "1989 POPULATION, ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT", (IN PRESS).

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1.3.6.2 Future Population and Land Use Projections

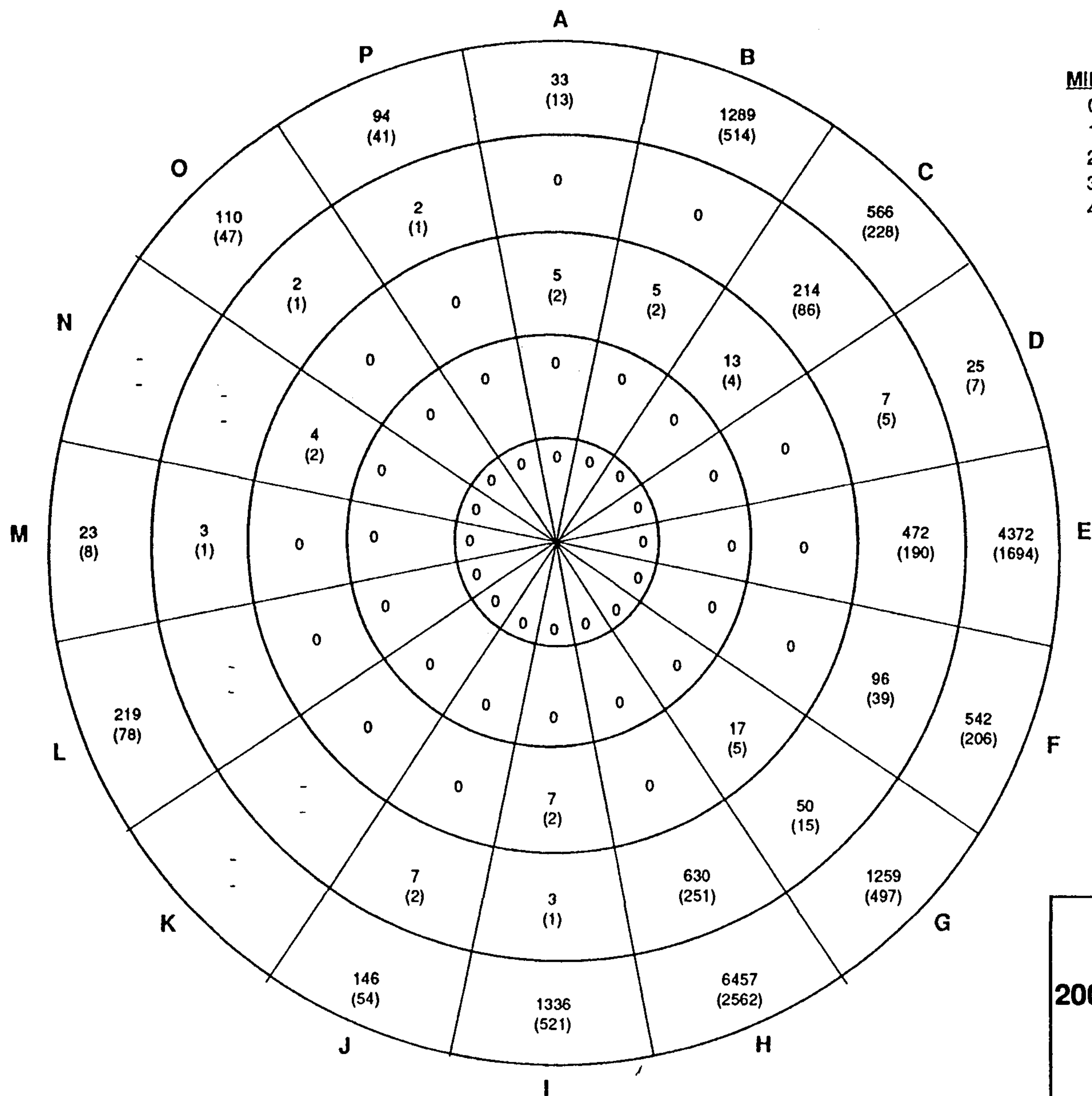
Future land use in the vicinity of the RFP most likely involves continued suburban expansion, increasing the density of residential, commercial, and perhaps industrial land use in the areas. The expected trend in population growth in the vicinity of the RFP is addressed in the DOE demographics study (DOE, 1991d). This report considers expected variations in population density by comparing the current (1989) setting to population projections for the years 2000 and 2010. A 21-year profile of projected population growth in the vicinity of the RFP can thus be examined. The DOE projections are based primarily upon long-term population projections developed by the Denver Regional Council of Governments (DRCOG). Expected population density and distribution around the RFP for the years 2000 and 2010 are shown in Figures 1-5 and 1-6, respectively. Table 1-1 summarizes the population data presented in Figures 1-4, 1-5, and 1-6.

1.3.7 RFP Hazardous Substances

RFP operations generate nonhazardous, hazardous, radioactive, and mixed radioactive waste streams (DOE, 1988). Hazardous substances which have been detected in the environment on the RFP as a result of RFP operations include various radionuclides, nonradioactive metals, Volatile Organic Compounds (VOCs), semi-volatile organic compounds, and inorganic ions. These substances have been detected through routine environmental monitoring conducted by the RFP (see Subsection 1.3.8) and/or during investigations of RFP OUs. Herbicides, which have been applied in the past at various locations on the RFP, have also been detected.

The IAG identifies 178 IHSSs at the RFP, 113 of which are within the RFP boundary. As mentioned in Subsection 1.2, these IHSSs have been grouped into 16 OUs. A number of the IHSSs consist of multiple release locations, which are grouped together as a single IHSS because of similar contaminant characteristics. RFP IHSSs have been identified primarily on the basis of RFP records and employee interviews. RFI/RI field activities have not yet commenced at most of the 16 RFP OUs, meaning that most of the IHSSs have been characterized only on the basis of historical

Miles	Sector Name
0-1	Sector 1
1-2	Sector 2
2-3	Sector 3
3-4	Sector 4
4-5	Sector 5



SOURCE: DOE, "1989 POPULATION, ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT", (IN PRESS).

Figure 1-5
2000 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

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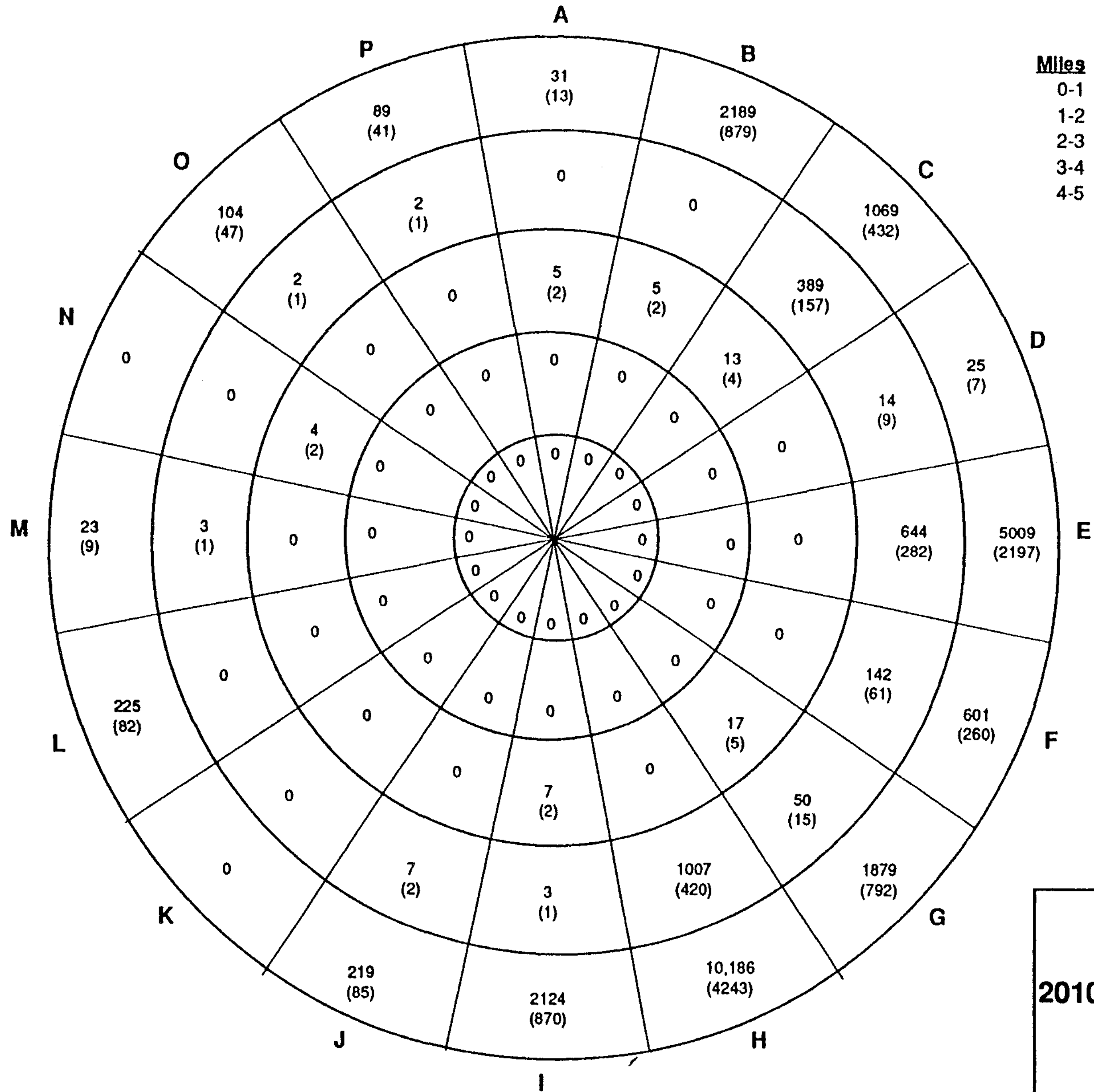

Miles	Sector Name
0-1	Sector 1
1-2	Sector 2
2-3	Sector 3
3-4	Sector 4
4-5	Sector 5

Figure 1-6
2010 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

SOURCE: DOE, "1989 POPULATION, ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT", (IN PRESS).

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TABLE 1-1

CURRENT AND PROJECTED POPULATION IN THE VICINITY OF THE ROCKY FLATS PLANT

Sector	Segment B	C	D	E	F	G	H	Sum
Year: 1989								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	22	0	283	46	50	215	616
5	300	13	25	3,671	477	578	2,355	7,419
SUM	305	48	25	3,954	523	645	2,570	8,070
Year: 2000								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	214	7	472	96	50	630	1,469
5	1,289	566	25	4,372	542	1,259	6,457	14,510
SUM	1,294	793	32	4,844	638	1,326	7,087	16,014
Year: 2010								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	389	14	644	142	50	1,007	2,246
5	2,189	1,069	25	5,009	601	1,879	10,186	20,958
SUM	2,194	1,471	39	5,653	743	1,946	11,193	23,239

Source: DOE (in press)

information, and that detailed information regarding the existence, concentration, and extent of contamination is not available for most IHSSs.

1.3.8 RFP Environmental Monitoring

The RFP conducts routine radiological and nonradiological environmental monitoring of effluent air, ambient air, surface water, groundwater, tap water, stream sediments, and soil at locations on and in the vicinity of the RFP. Results from these monitoring programs are published monthly and/or annually in RFP environmental monitoring reports (Dow et al., 1971 to date). Ambient air, soil, and surface water quality are also monitored in locations around the RFP by CDH and by cities utilizing Great Western Reservoir and Standley Lake as municipal water supplies. The following information about these programs is taken primarily from RFP monthly and annual environmental reports.

1.3.8.1 Ambient Air Monitoring

The RFP maintains a network of continuously operating ambient air samplers on and in the vicinity of the plant site. These samplers trap influent particulates on a filter element. Specific information regarding sampler types and locations, analytical protocols, and analytical results have been summarized since 1971 in the RFP annual environmental monitoring reports (Dow et al., 1971 to date). There currently are 53 samplers in the ambient air sampling network, of which 25 are located on the RFP site (Figure 1-7), 14 are located along the RFP boundary (Figure 1-7), and 14 are located within nearby communities (Figure 1-8). The RFP has conducted onsite ambient air monitoring since the plant opened in 1951. The original network of low-volume (approximately 2 cubic feet per minute [cfm]) air samplers was upgraded in 1974 and 1975 to the high-volume (approximately 25 cfm) samplers currently in use. Offsite (community) samplers were added to the network at this time.

Sampling and analytical protocols have varied throughout the history of the ambient air monitoring program. Plutonium analysis of selected ambient air samples began in 1975; before this, onsite ambient air samples were analyzed for total long-lived alpha radiation only. Under the current protocol, onsite samples are collected biweekly and analyzed for isotopic plutonium. As of December

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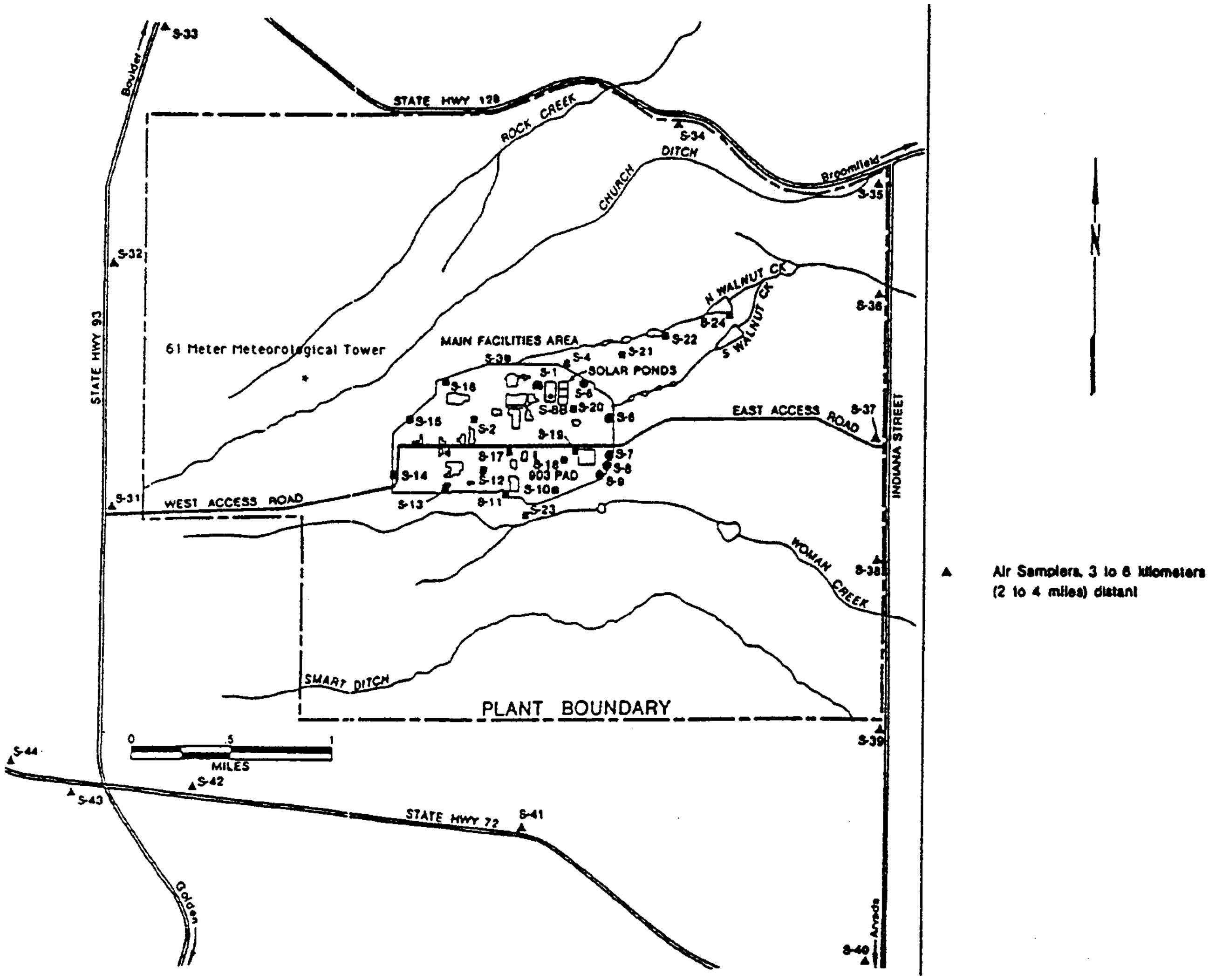

NOTE: PORTIONS OF FIGURE ARE NOT TO SCALE

Figure 1-7
LOCATION OF ONSITE AND PLANT PERIMETER AMBIENT AIR SAMPLERS

SOURCE: EG&G ROCKY FLATS, "ROCKY FLATS PLANT MONTHLY ENVIRONMENTAL MONITORING REPORT".

DRAWN BY	KRONER 3-4-91
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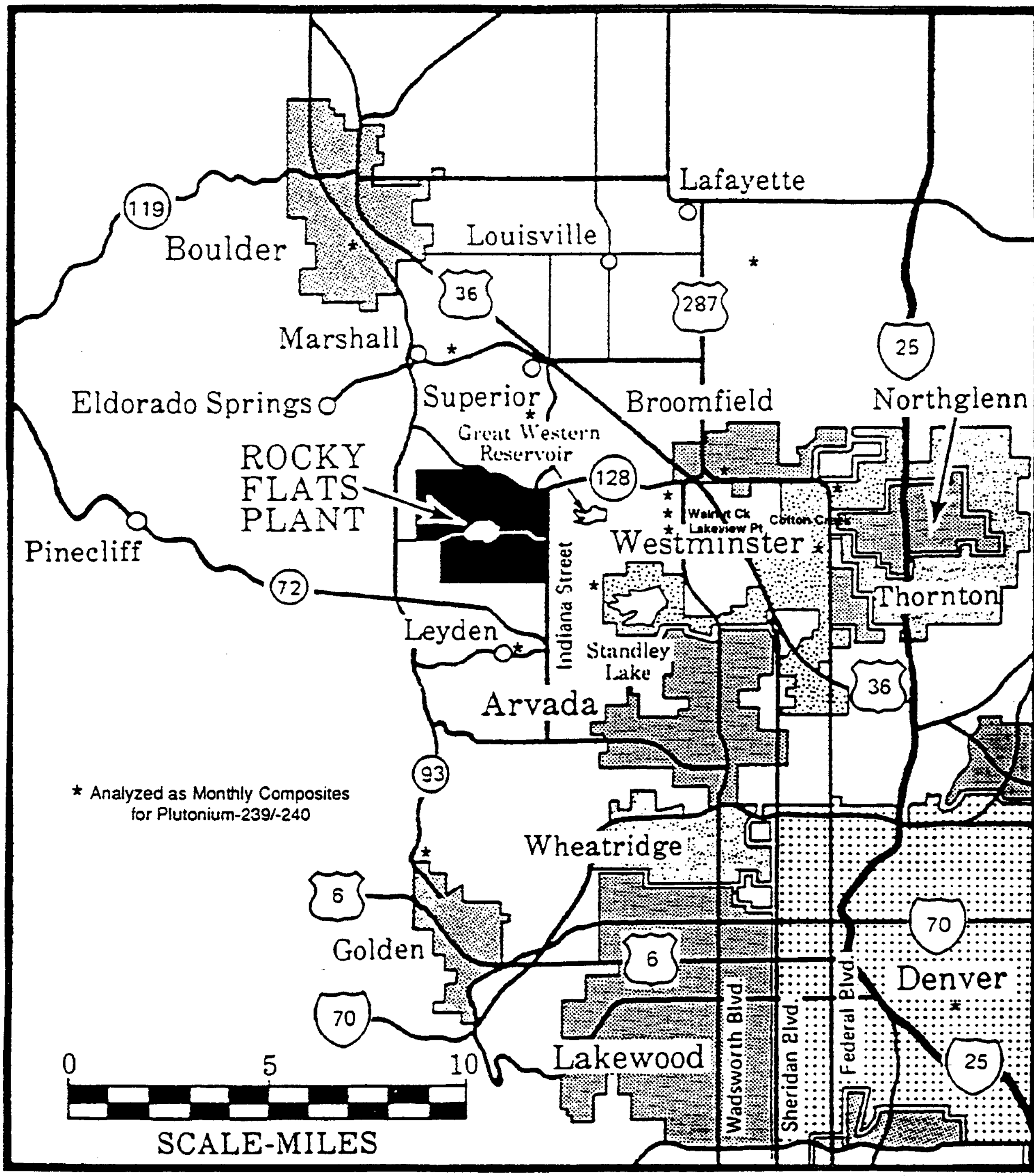

Figure 1-8
LOCATION OF COMMUNITY AMBIENT AIR SAMPLERS

SOURCE: EG&G ROCKY FLATS, "ROCKY FLATS PLANT MONTHLY ENVIRONMENTAL MONITORING REPORT".

1990, the biweekly onsite samples are composited into a single monthly sample. Samples from the RFP perimeter and from nearby communities are collected biweekly and composited into single monthly samples from each sample station, which are analyzed for plutonium. The CDH also maintains offsite air samplers for measuring plutonium concentration in ambient air in the vicinity of the RFP (CDH, 1970 to date). These samples are analyzed for gross alpha and beta in addition to the plutonium.

Starting in the early 1980s, the RFP conducted onsite monitoring for EPA criteria pollutants (total suspended particulates, ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, and lead) utilizing a mobile ambient air monitoring unit. This mobile unit was replaced in mid-1986 with a permanent monitoring station located just inside the RFP east gate. Starting in 1989, this program was scaled back to include total suspended particulates and respirable particle fraction (those particles smaller than or equal to 10 microns in size) only.

In 1976, nine ambient air monitoring stations were installed by the RFP at and near IHSS 199 acreage, which was the subject of a lawsuit by owners of land adjacent to the plant. These stations were operated from November 1976 through July 1978 specifically to collect monthly airborne plutonium concentration data for the lawsuit. It was determined in 1978 that data collected from the lawsuit-specific stations did not significantly differ from nearby ambient air monitoring program sampler data, and the lawsuit-specific stations were, therefore, removed (Rockwell, 1978).

Airborne plutonium concentrations were monitored by the RFP immediately downwind of the remedy acreage during court-ordered tilling to supplement data obtained from permanent stations downwind of the acreage. A tabulation of the 1987 remedy-specific monitoring data is included in Rockwell (1988b). A summary of average annual ambient air plutonium concentrations from selected monitoring stations near the remedy acreage during the period of remedial activity (1985 to 1988) is provided in Rockwell (1989a).

1.3.8.2 Effluent Air Monitoring

Effluent air at the RFP has been monitored since it opened in 1951. Effluent air monitoring is addressed in detail in RFP monthly and annual environmental monitoring reports (Dow et al., 1971 to date) and in the RFP Environmental Impact Statement (EIS) (DOE, 1980). Continuous effluent air samplers are located in the ventilation exhaust systems of each production and research building at the RFP. As is the case with the ambient air monitoring program, the sampling and analytical protocols for effluent air monitoring have varied throughout the history of the RFP. Plutonium analysis of selected effluent air samples began in 1975; before this, airborne effluents were analyzed for total long-lived alpha radiation only. Under current protocol, effluent air samples are analyzed at regular intervals for total long-lived alpha activity. Individual samples from each exhaust system are composited monthly into area-specific samples, which are analyzed for plutonium, americium, uranium, and beryllium. Exhaust streams known to potentially contain tritium are also analyzed for tritium concentration three times each week.

1.3.8.3 Soil Monitoring

Beginning in 1984, soil samples have been collected annually by the RFP to evaluate changes in soil plutonium concentrations. The soil monitoring program is addressed in detail in the RFP annual environmental monitoring reports (Dow et al., 1971 to date). Under current protocol, soils samples are collected once per year from 40 sites located on concentric circles 1 and 2 mi (1.6 and 3.2 km) from the center of the RFP and are analyzed for plutonium. A similar soil sampling program was conducted in 1977, with the addition of 17 samples collected from locations on a circle 5 mi (8 km) from the RFP center.

The CDH also monitors soil plutonium concentrations in areas near the RFP (CDH, 1990a). Under this program, five subsamples are collected within each of 13 predefined sectors near the RFP and composited into a single sample, which provides an average soil plutonium concentration within the sector. Soil samples also are collected from eight Colorado locations remote from the RFP in order to assess soil plutonium concentrations due to worldwide atmospheric fallout. The CDH soil sampling program was conducted annually between 1970 to 1978, and in 1980, 1981, 1986, and 1989. Results are published in RFP environmental surveillance reports prepared monthly by CDH, (CDH, 1970 to date). A summary table of results between 1970 to 1986 is included in CDH (1990). Several of the past sampling programs, including the 1989 program, have included analysis of selected radionuclides other than plutonium, and beryllium (CDH, 1990a). The results of the beryllium analyses were all below method detection limits.

1.3.8.4 Surface Water Monitoring

Routine monitoring of surface water within and around the RFP, of all effluent streams leaving the RFP, and local municipal water supplies around the RFP has been conducted since shortly after the RFP opened in 1951. Specific sampling and analytical protocols have varied throughout the history of the surface water monitoring program. Information regarding sample locations, analytical protocols, analytical results, and compliance with applicable state and federal water quality standards has been summarized since 1971 in the RFP monthly and annual environmental monitoring reports (Dow et al., 1971 to date). The surface water monitoring program is also summarized in the EIS for the RFP (DOE, 1980).

Water quality in Great Western Reservoir and offsite reaches of Walnut Creek is routinely monitored by the RFP, the City of Broomfield, and the CDH. Broomfield samples Walnut Creek at a location immediately east of the RFP on a monthly basis and tests for eight VOCs. An automatic sampler at the same location collects a composite water sample each week for gross alpha and gross beta analysis. Weekly samples also are collected by Broomfield from Walnut Creek below Great Western Reservoir and analyzed for gross alpha and gross beta. Water entering the Broomfield water treatment plant from the reservoir is monitored monthly for eight VOCs. Treated Broomfield tap water also is monitored weekly for gross alpha and gross beta, and monthly for eight VOCs (CDH, 1989). The CDH conducts quarterly sampling of Great Western Reservoir for selected herbicides, pesticides, metals, base neutral acids (BNAs), and radionuclides. Broomfield water treatment plant influent from Great Western Reservoir is analyzed weekly by the CDH for selected radionuclides (CDH, 1990b).

The cities of Northglenn, Thornton, and Westminster each monitor raw water influent from Standley Lake at their respective water treatment plants for VOCs, gross alpha, and gross beta. Westminster also monitors treated tap water for gross alpha and gross beta. Woman Creek is sampled immediately east of the RFP boundary once each month by the City of Thornton and is analyzed for 59 VOCs. Another location along Woman Creek is sampled weekly for gross alpha and gross beta analysis. Standley Lake water was sampled monthly near the Westminster treatment plant inlet and analyzed for 59 VOCs. The Cities of Thornton, Northglenn, and Westminster recently eliminated VOCs from their sampling programs because they have not been detected. Water is also sampled monthly near the Standley Lake dam at six different depths and analyzed for gross alpha and gross beta (CDH, 1989). The CDH conducts quarterly sampling of Standley Lake for analyses of selected herbicides, pesticides, metals, BNAs, and radionuclides. Westminster water treatment plant influent from Standley Lake is analyzed weekly by the CDH for selected radionuclides (CDH, 1990b).

The RFP, CDH, and municipal monitoring programs have produced a large volume of data to assess the potential impacts from RFP releases on surface water. The monitoring is conducted in part to ensure that the RFP meets applicable state and federal water quality standards. Applicable standards have varied since the opening of the RFP in 1951. Current applicable standards for the RFP include:

- **The National Pollution Discharge Elimination System (NPDES) standards** for the RFP, first issued in 1974, which limit nonradioactive discharges from the plant

- **State drinking water standards** for radioactive contaminants in community water systems, promulgated in 1977

- **Colorado Water Quality Control Commission (CWQCC) water quality standards** for both radioactive and nonradioactive contaminants, which were adopted in July 1989 for the upper segments of Big Dry Creek basin

Descriptions of these standards, and information about the RFP's compliance with the standards, are contained in the RFP Monthly and Annual Environmental Monitoring Reports (Dow et al., 1971 to date).

1.3.8.5 Groundwater Monitoring

A total of 56 groundwater monitoring wells were installed at the RFP between 1960 and 1985. Most of these wells were located within the controlled area of the plant (Figure 1-1) and targeted specific sites of suspected groundwater contamination. Limited completion data and sampling data are available for these pre-1986 wells. The sampling frequency for these wells varied from quarterly to biannually. Until 1985, samples were analyzed for selected radionuclides only; beginning in 1985, other chemical parameters (volatile organic compounds, metals, and inorganics) were added (Rockwell, 1989b).

In 1986 and 1987, 137 monitoring wells were installed as part of the DOE Comprehensive Environmental Assessment and Response Program (CEARP) for the RFP. CEARP later became the ER Program (Subsection 1.1). These wells were drilled in part to meet RCRA requirements for the four regulated units at the RFP, and also targeted other known IHSSs at the plant. The 1986 wells included four wells along the eastern boundary of the RFP (downgradient of the main production facility) to assess potential contaminant movement offsite through groundwater. Also included were background characterization wells in onsite areas believed to be unaffected by activities from the RFP (Rockwell, 1989b). An additional 160 wells were installed in 1989 to further characterize the hydrogeology of the RFP, including three additional wells along the eastern boundary of the RFP (EG&G, 1990b).

The current network of 371 monitoring wells is sampled quarterly and analyzed for field parameters selected radionuclides, metals, organics, inorganics, and anions. Semivolatile and pesticide/PCB analyses taken the first quarter after a well is installed. Monthly and/or quarterly water level measurements are taken when the wells are sampled. Monthly water levels are taken in selected wells (114 wells) to assess groundwater flow direction. More detailed information regarding the RFP groundwater monitoring program is provided in the RFP Annual Environmental Monitoring Reports (Dow et al., 1971 to date). Groundwater monitoring results for RCRA-regulated units at the RFP have been provided since 1988 in annual RCRA groundwater monitoring reports (Rockwell, 1989b; EG&G, 1990b).

1.3.9 Other OU Activities and Relevant Work

Sixteen OUs have been identified at the RFP under the Rocky Flats IAG as in Subsection 1.2. Under the IAG, the DOE is required to conduct a RI/FS/RFI/Corrective Measures Study (CMS) for the OUs. The OUs that OU 3 will interact with include OUs 2, 4, 5, and 6.

Operable unit 2 studies are investigating Pad 903, which is believed to be the source area for contamination associated with OU 3. OUs 5 and 6 studies are investigating Woman Creek and Walnut Creek, respectively. The drainages from these creeks flow offsite and into OU 3. Work efforts for OU 3 will be coordinated with efforts at OUs 2, 4, 5, and 6. As information from other OUs becomes available, the data will be reviewed and incorporated into OU 3 work, as appropriate. OU4 studies are investigating two solar evaporation ponds.

Other relevant activities affecting OU 3 include the work being done as part of the Option Review Group. In April 1990, Congressman David Skaggs organized a committee to develop and evaluate surface water management options for the Woman Creek and Walnut Creek watersheds. The Option Review Group was formed from this committee. The Option Review Group developed and evaluated at least eight options for management of surface water flows from the RFP. The group recommend Option B, which would protect the Standley Lake drinking water reservoir and replace the drinking water supplied by Great Western Reservoir.

Option B is a combination project that would detain and divert Woman Creek flows to protect Standley Lake during a 100-year flood event, and replace Great Western Reservoir as a drinking water supply. Activities for OU 3 will be coordinated with work associated with Option B.

One piece of Option B is the Standley Lake Diversion Canal. Construction of the canal could begin as early as September 1992. DOE, EG&G, and the cities associated with the Standley Lake Diversion Canal Project are all working together to collect the field data necessary for performing a risk assessment prior to beginning construction activities. DOE, EG&G, and the cities are meeting regularly to discuss schedule and coordination issues. For example, Field Sampling Plans and permitting issues are being reviewed and coordinated by all parties.

Several other components of Option B will likely be implemented in the 1993 to 1994 timeframe. These Option B components will review and consider the OU 3 RFI/RI findings.

2.0 SITE CHARACTERIZATION

OU 3 is unique among RFP OUs in that it is located outside the RFP boundaries. The locations of each of the four IHSSs (Sites) in OU 3 relative to the RFP are shown in Figure 2-1. Subsections 2.1 through 2.4 describe site conditions, previous environmental investigations, and available information regarding the nature and extent of contamination for IHSSs 199 through 202, respectively. Conceptual models for contaminant fate and mobility in soils (IHSS 199) and reservoirs (IHSSs 200 to 202) are developed in Subsection 2.5.

2.1 IHSS 199 (CONTAMINATION OF THE LAND'S SURFACE)

IHSS 199, Contamination of the Land's Surface, specifically targets offsite soil contamination as a result of RFP past releases. Included within IHSS 199 are approximately 350 ac (142 ha) of land, which were part of a 1975 lawsuit filed in U.S. District Court (Civil Action No. 75-M-1162) by the land owners against the United States and other defendants (hereafter referred to as the lawsuit), alleging contamination of the land surface by releases from the RFP during its operating history. Several technical investigations and studies of the lawsuit acreage were conducted by the various parties to the lawsuit to provide supporting evidence in the case. A settlement agreement finalized in July 1985 (the Settlement Agreement) (U.S. District Court, 1985a) required that the RFP undertake remedial action on those portions of the land (hereafter referred to as the remedy acreage) containing surface plutonium at concentrations exceeding an action level adopted by the court from a CDH special construction standard for plutonium in soil of 0.9 picocuries per gram (pCi/g) (0.03 Becquerel per gram [Bq/g]). Two contiguous tracts of land, which currently are owned by the City of Broomfield and Jefferson County, were targeted for remediation based upon the CDH standard. To date, remedial activities have been undertaken on 120 ac (49 ha) of Jefferson County remedy acreage (Subsection 2.1.2.2).

2.1.1 Location and Description

As presently defined, IHSS 199 includes all soils outside of the RFP boundary that are contaminated by past releases from the RFP. The IHSS 199 boundary, therefore, is delineated by the extent of offsite contamination, which has not been conclusively defined. Previous work, which has attempted to determine this extent, is detailed in Subsection 2.1.4.2. Past attempts to define the presence and extent of offsite soil contamination have focused almost exclusively on airborne plutonium emissions from the RFP.

The remedy acreage is located on two tracts of land totalling 350 ac (142 ha) in the southern half of Section 7 and the western half of Section 18, Township 2 South, Range 69 West (T2S, R69W). Both areas are just outside the eastern boundary of the RFP, approximately 1.5 mi (2.4 km) east of the main production area of the plant (Figure 2-1). Both are generally downwind and downgradient of the RFP.

2.1.2 Significant Historical Events for IHSS 199

Under the terms of the 1985 Settlement Agreement with landowners, a 250-ac (101 ha) tract of land was transferred to Jefferson County for use in its Open Space program, and 100 adjoining ac (41 ha), were allotted to the City of Broomfield for future expansion of Great Western Reservoir. These lands were deeded with the understanding that the RFP would implement remedial activities on these 350 ac (142 ha), as specified in the Settlement Agreement, at the request of the owners. Jefferson County requested in 1986 that remediation commence on the portions of their acreage targeted for remediation. To date, the remedy has been implemented on 120 of the 250 ac of Jefferson County land. Rather than allow immediate use of the acreage as Open Space, the county has chosen to not allow public access to this land until the remediation is completed. To date, Broomfield has not requested that the RFP begin remediation on their affected acreage, and has not proceeded with plans to expand Great Western Reservoir. Broomfield does not allow public access to this land.

The following sections summarize the legal history of IHSS 199 and describe the remedial actions undertaken to date at the site as a result of the Settlement Agreement.

2.1.2.1 History of Litigation

In May 1975, a lawsuit was filed against Rockwell International Corporation, Dow Chemical Company, and the United States of America by the Church (McKay) plaintiffs and Great Western Venture partnership (U.S. District Court, 1985b). The plaintiffs' holdings consisted of approximately 2,000 ac (810 ha) to the west, south and east of the RFP. The plaintiffs alleged that their lands were damaged by releases of plutonium and other radioactive materials from the RFP. The plaintiffs claimed that these materials had rendered their land unfit for human habitation and had diminished the market value of their properties for commercial, residential or other nonagricultural uses. The plaintiffs further claimed that the mere presence of the RFP next to their property further diminished the value of their properties. The defendants acknowledged that releases of radioactive materials occurred at various times from the 1950s through the late 1960s, but contended that the releases had not violated applicable regulations established for the protection of the public (U.S. District Court, 1985b).

On the basis of scientific exhibits presented early in the proceedings and objections raised during the hearings, the parties agreed to conduct a field investigation on the plaintiffs' lands that would include collection and analysis of soil samples for plutonium and americium. Before commencement of the field investigation, the parties agreed to specific methodologies for collecting, preparing, and analyzing the soil samples (Rockwell, 1979). The field investigation program commenced in 1977 and continued through 1979. Results of the program indicated plutonium concentrations on the plaintiffs' properties ranging from <0.01 to 3.4 pCi/g (3.7×10^{-4} to 0.13 Bq/g) (CDH, 1977; Rockwell, 1979a; Rockwell, 1979b). After additional testing, the parties agreed to accept some of the data as evidence for the trial (U.S. District Court, 1985b).

In March 1978, the Ackard-Butler interests intervened in the legal proceeding and were added to the lawsuit as plaintiffs. Church and Ackard-Butler added, by amended complaint, the State of Colorado and Jefferson County, Colorado, as defendants in 1982, claiming that if the Government defendants prevailed in this litigation, then the State and County had acted unlawfully in precluding development of plaintiffs' lands. In 1982, the Court dismissed the plaintiffs' claims for lack of jurisdiction, ruling that the issues were not determinable under Rule 56. In 1983, the Tenth Circuit Court of Appeals reversed this ruling, stating that the plaintiffs were entitled to a trial or trials on some of their claims.

In December 1984, a settlement was reached between the defendants and plaintiffs (U.S. District Court, 1985a). The Settlement Agreement, as amended on July 2, 1985, called for ripping, plowing and disking (referred to generically in this report as "tilling") of affected soils to reduce plutonium concentrations to less than the CDH special construction requirements standard of 0.9 pCi/g (0.03 Bq/g). Historical incidents (such as in Palomares, Spain, circa 1960) established a precedent for tilling plutonium contaminated lands, which reduces the concentration of plutonium by dispersing it throughout the soil (Lawton, 1990). Results of soil sampling during 1977 indicated that plutonium levels in several tilled wheat fields on the plaintiffs' property were consistently lower than levels on adjacent undisturbed ground. The agreement required the RFP to conduct additional soil sampling to verify that plutonium concentrations were reduced, and to revegetate the tilled soils to provide stabilizing vegetation. Specific standards for evaluating the success of revegetation were not included in the agreement. The option of remediating the land through "other processes" was left open in the agreement. The selected remedial actions were jointly agreed upon by Rockwell International, DOE, and CDH. One of the conditions of the agreement was the preparation and dissemination by the RFP of an annual status report on remediation progress. The RFP currently provides semiannual status reports. The Settlement Agreement also made provisions in the event there are any future release(s) from the RFP. If a release occurs, the RFP must demonstrate that contaminants on affected properties do not exceed applicable standards.

Court-supervised soil sampling was conducted in 1985 on the affected lands according to CDH sample collection protocol (Rockwell, 1985a; Rockwell, 1985b). Approximately 350 ac (142 ha) of land with concentrations of plutonium greater than 0.9 pCi/g (0.03 Bq/g) were delineated by the sampling program. These areas, which were subsequently transferred to Jefferson County and the

City of Broomfield, are the only land to which the Court-ordered remedial action applies. Another 490 ac (198 ha) pertinent to the settlement did not exceed the soil plutonium concentration limit and, therefore, were not targeted for remedial action.

The 1985 sampling data corroborated earlier observations that areas originally cultivated with wheat contained substantially lower concentrations of near-surface plutonium. It was also noted that average plutonium concentrations in the surficial soil appeared to have decreased significantly between 1977 and 1985. This apparent decrease may have been due to plutonium migration (see discussion in Subsection 2.5.1.4). The lower values may also have resulted from: (1) the use of different laboratories utilizing differing analytical techniques; (2) the significantly larger area represented by the 1985 samples (10 ac [4 ha] per sample) as compared to the 1977 samples (0.2 ac [0.08 ha] per sample) (Rockwell, 1987a); or, (3) soil sampling techniques used during the two studies.

On May 28, 1986, Jefferson County requested that the remedial actions be undertaken on their lands (Rockwell, 1988c). To date, the City of Broomfield has not requested that their lands be remediated.

2.1.2.2 Remediation of Jefferson County Lands

Soil remediation currently is underway on approximately 250 ac (101 ha) of Jefferson County lands. The following sections address the scope of the remedial activities and the history and present status of the remediation.

2.1.2.2.1 Scope of Soil Remediation. The July 1985 amended Settlement Agreement outlines a specific course of remedial action for plutonium contaminated lands. The nature and scope of remedial actions were developed and agreed upon by Rockwell International, DOE, and CDH. Recommendations concerning erosion control and revegetation were provided by the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) on behalf of Rockwell. It should be noted that, because of concerns over soil stabilization, the SCS concluded that it would be best to leave the affected lands undisturbed rather than to attempt remediation (SCS, 1985).

The Settlement Agreement specifies the following remedial actions (U.S. District Court, 1985b):

- Spring ground preparation (plowing and disking ["tilling"] to reduce plutonium concentrations through mixing and dilution) plus a summer (June) cover crop
- Drilling grass seed into cover crop stubble in the fall
- Supplemental mulch
- Timely irrigation during the establishment period
- Weed control to ensure successful establishment of grasses.

More specifically, the Settlement Agreement requires that the remediation shall consist of the following remedial actions, any of which may be modified by agreement between the owner of the land and the RFP:

- **Erosion Control**–Small areas of land may be worked on all at once, but larger areas will require a phased approach. Land shall be broken out in alternating strips perpendicular to the prevailing winds or, on long slopes, on the contour. Strip widths shall be determined by a number of site-specific variables, including soil characteristics, slope length and gradient, vegetative cover, and field width. Work on the other set of strips shall not begin until the first set is successfully reestablished in grass. Properly done, this will minimize erosion in "normal" weather. There shall be some standby provisions for emergency erosion control such as extra mulching and sediment-trapping diversions, in the event of unusual weather.
- **Soil Preparation**–May is the logical time for the plowing, disking, chiseling, and harrowing operations necessary to satisfy the soil mixing objective of the remedial action plan and to prepare a seedbed for the cover crop. The frequency of tillage

required depends on successful reduction of soil plutonium concentrations to the remedy action level. Additions of nitrogen and phosphorous shall be made as necessary.

- **Cover Crop**–The revegetation scheme utilizes a cover crop (forage sorghum), which will be planted in June when the soil has warmed to 60°F (16°C).

- **Grass Seeding**–Grass shall be drilled into the ground after November 1.

- **Mulch**–The cover crop should leave adequate residue for soil protection. If it is insufficient in some areas, mulch will be needed.

- **Supplemental Irrigation**–Timely irrigation through establishment of the grass seed mix shall be used to improve the chances for a successful planting. Supplemental irrigation may also be required during establishment of the cover crop.

- **Special Conditions**–In order to prevent possible resuspension of plutonium on the soil surface, the mixing operation will be conducted only when the soil moisture content is greater than 15 percent and the wind velocity is less than 15 miles per hour (mph) (24 km per hour). Portable air samplers will be operated downwind from the soil mixing operations during all phases of the program. The samples will be analyzed for plutonium and all activities will be shut down if the plutonium concentration in the air exceeds a control level of 0.02 pCi/cubic meter (7.4×10^{-4} Bq/cubic meter).

- **Maintenance**–Areas that do not develop satisfactory ground cover in a reasonable length of time (two growing seasons) would be reseeded after an evaluation of the circumstances by representatives of Rockwell (now EG&G) and the land owners involved.

2.1.2.2.2 Effectiveness of the Remedy Implementation. Court-ordered remedial actions taken to date on the Jefferson County remedy acreage are summarized in Table 2-1. These actions are addressed in much greater detail in the remedy status reports prepared by the RFP under the terms of the Settlement Agreement. Six remedy status reports have been prepared to date (Rockwell, 1987a; Rockwell, 1987b; Rockwell, 1988d; Rockwell, 1989c; EG&G, 1990c; EG&G, 1991c).

As indicated in Table 2-1, remedy actions have been implemented on two plots of Jefferson County remedy acreage; a 20 ac (8 ha) plot in Section 18, T2S, R69W (the southern area) and a 100-ac (41 ha) plot in Section 7, T2S, R69W (the northern area). The southern and northern areas have been tilled in strips as an erosion control measure, as shown in Figures 2-2 and 2-3, respectively. Tilling of these 120 ac appears to have successfully reduced soil plutonium concentrations to below the 0.9 pCi/g (0.03 Bq/g) CDH standard adopted by the court as a remedy action level. Attempts to stabilize the tilled soils through revegetation have met with mixed success to date. The outcome of the revegetation effort appears to result from the following factors (EG&G, 1990c; EG&G, 1991c):

- Insufficient amounts and/or seasonal distribution of precipitation
- Extremely rocky surfaces or clayey soils
- Intense competition from weeds
- An expanding prairie dog population
- The effects of slope on soil moisture.

The 1990 remedy status report (EG&G, 1990c) proposed specific actions to improve the revegetation effort, which at the time was estimated to be only 10 percent successful. Between 1988 and 1990, the RFP operating contractor changed from Rockwell International to EG&G, and several key personnel changes occurred within the EG&G group responsible for implementation of the remedy. As a result, the remedy actions proposed in the 1990 report were not implemented.

The January 1991 remedy status report (EG&G, 1991c) provides the latest available assessment of the revegetation effort. This report indicates that, after a successful 1990 growing season, planted grasses have become established on approximately 50 percent of the northern (Section 7) acreage,

TABLE 2-1

IHSS 199 REMEDY ACTIONS

Dates	Activity	Result
June 1986	Soil tilling and subsequent seed bed preparation of the northern area (approximately 100 ac) in Section 7.	Partial success; approximately 80 ac were successfully remediated and approximately 20 ac exceeded the plutonium concentration standard.
July 1986	Initiated application of sorghum seed on the approximately 80 ac successfully remediated in Section 7.	First sprouts appeared 08/04/86.
July 1986	Second tilling operation of the approximately 20 ac in Section 7 where the initial effort was unsuccessful. This operation consisted of tilling the area three more times.	Unsuccessful, plutonium concentration exceeded the standard.
July 1986	Third tilling operation of the approximately 20 ac in Section 7. This operation consisted of deep plowing an additional three times and one application of a Vibrashank ripper.	Successfully remediated.
August 1986	Planted the additional 20 ac in Section 7 with sorghum seed.	Sorghum stopped growing in October and wilted after the first frost.
October to November 1986	Applied wild grass seed to the approximately 20 ac in Section 7.	Failure.
June 1987	Reripped the approximately 100 ac in Section 7 and replanted sorghum seed.	Successful, sorghum came up well.
June to July 1987	Plowed and ripped the southern area (approximately 20 ac) in Section 18.	Partial success; approximately 15 ac were successfully remediated and the remaining approximately 5 ac exceeded the plutonium concentration standard.
July 1987	Replowed and reripped approximately 5 of the 20 ac in Section 18 which exceeded the plutonium concentration standard.	Successfully remediated.

TABLE 2-1

IHSS 199 REMEDY ACTIONS
(Concluded)

Dates	Activity	Result
November 1987	Conducted weed control on the approximately 100 ac in the North Area in Section 7 that were remediated. The area was sprayed with Roundup herbicide. The primary target was cheatgrass.	Very successful.
November 1987	Conducted weed control by discing the approximately 20 ac of remediated land in the South Area in Section 18.	Unknown.
November to December 1987	Performed erosion control measures consisting of planting winter wheat and the placement of mulch on the surface of the 20 ac of remediated land in Section 18.	Successful, subsequent inspections revealed little erosion was occurring.
April 1988	Reseeded grasses on the approximately 120 ac of remediated land in Sections 7 and 18.	Poor to marginal success, native grasses successfully established on only about 10 percent of the area.[a]
January 1991	Collected soil samples from both tilled and untilled areas in the Jefferson County acreage. This was performed because soil samples collected in 1986 and 1987 do not meet current quality assurance protocols.	Analytical results shown in Figures 2-4 through 2-7.
November 1991	Re-seeded grasses, shrubs and forbs on approximately 71 ac of remedy lands in Sections 7 and 18.	

[a] Past Remedy Report, Operable Unit No. 3–IHSS 1999 (Appendix D, Document D-16) (DOE, 1991a) indicates that a successful 1990 growing season significantly reduced the amount of area requiring reseeding.

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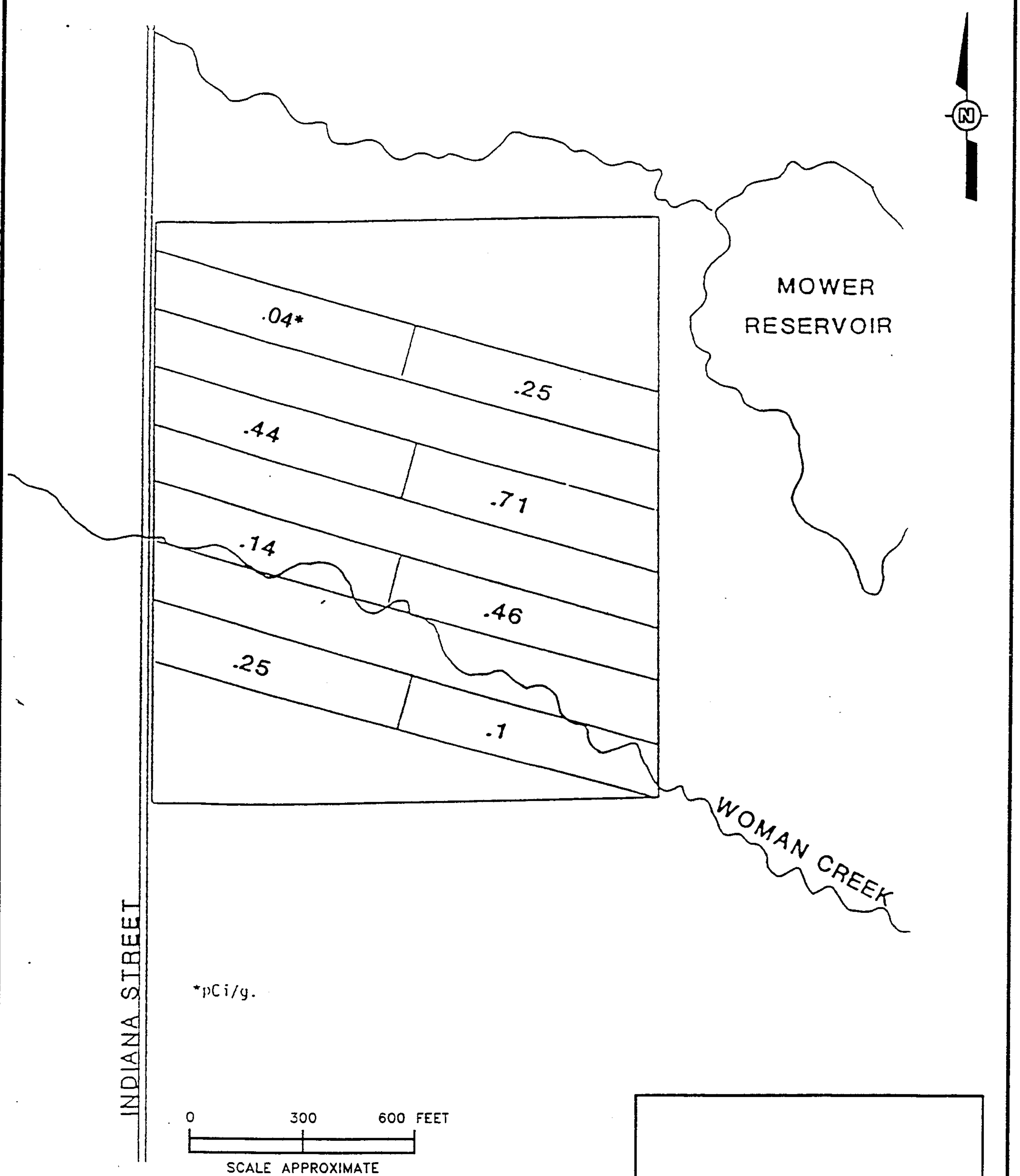
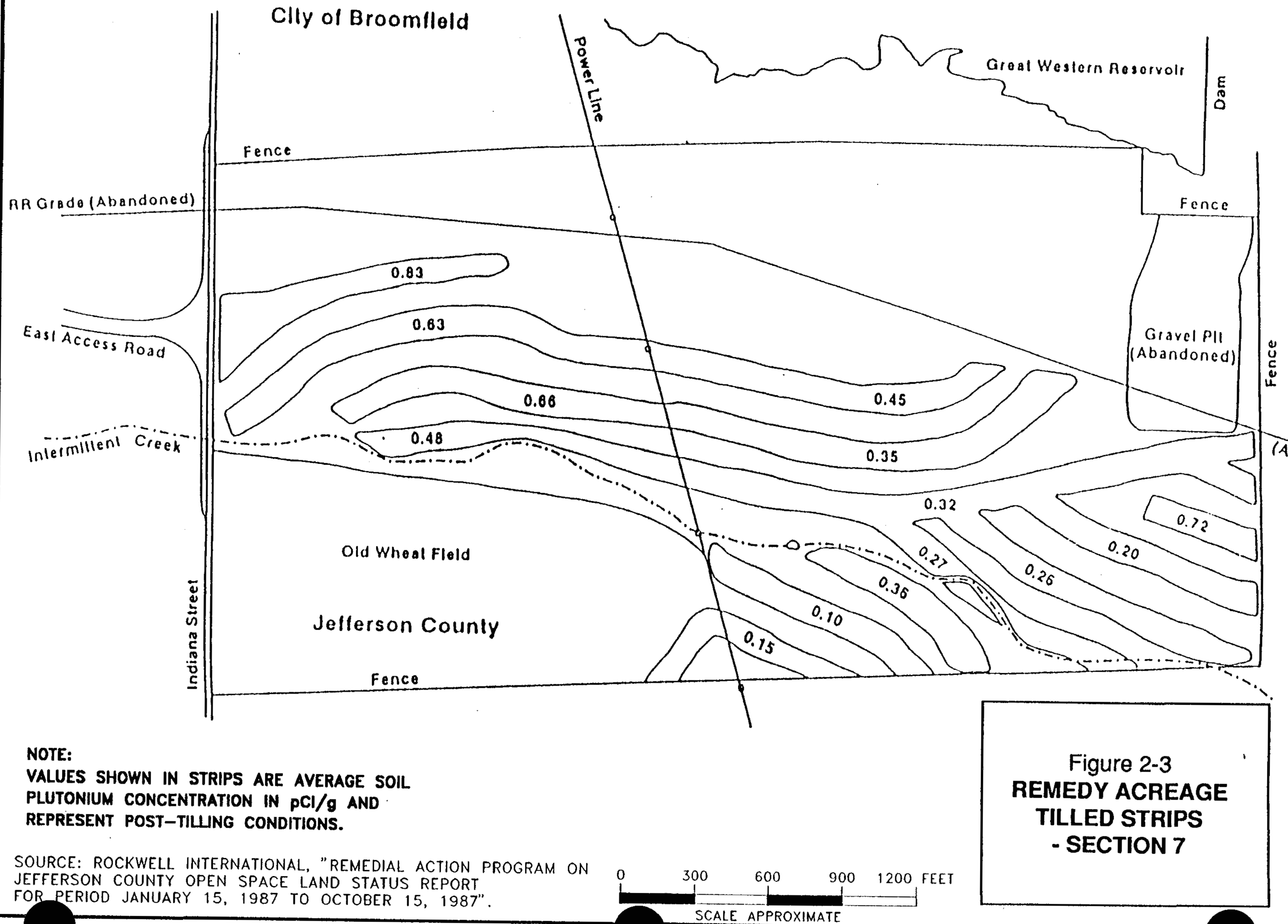


NOTE:
VALUES SHOWN IN STRIPS ARE AVERAGE SOIL PLUTONIUM CONCENTRATION IN pCi/g AND REPRESENT POST-TILLING CONDITIONS.

SOURCE: ROCKWELL INTERNATIONAL, "REMEDIAL ACTION PROGRAM ON JEFFERSON COUNTY OPEN SPACE LAND STATUS REPORT FOR PERIOD JANUARY 15, 1987 TO OCTOBER 15, 1987".

Figure 2-2
REMEDY ACREAGE TILLED STRIPS - SECTION 18

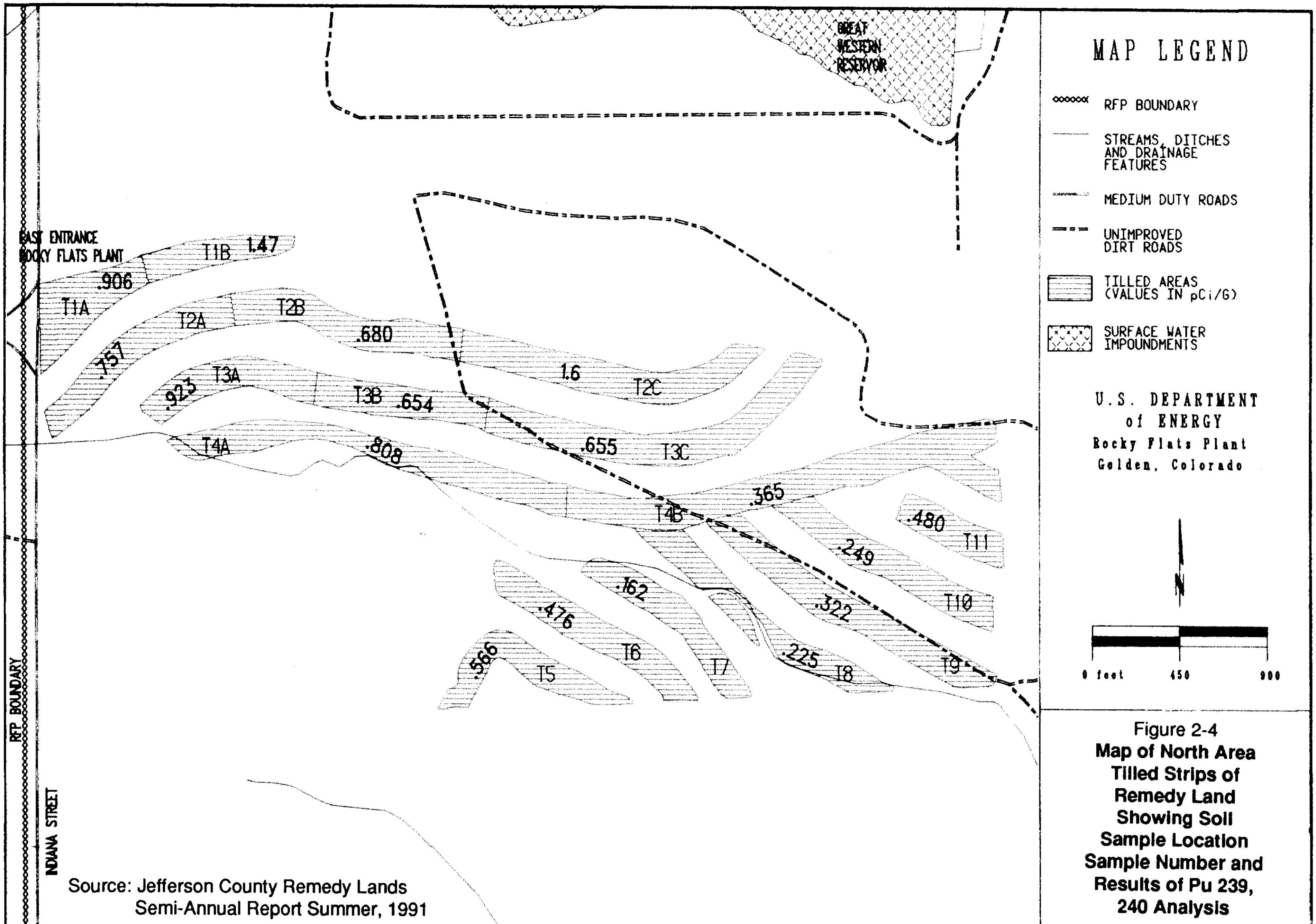


NOTE:
VALUES SHOWN IN STRIPS ARE AVERAGE SOIL PLUTONIUM CONCENTRATION IN pCi/g AND REPRESENT POST-TILLING CONDITIONS.

SOURCE: ROCKWELL INTERNATIONAL, "REMEDIAL ACTION PROGRAM ON JEFFERSON COUNTY OPEN SPACE LAND STATUS REPORT FOR PERIOD JANUARY 15, 1987 TO OCTOBER 15, 1987".

Figure 2-3
REMEDY ACREAGE TILLED STRIPS - SECTION 7

DRAWN BY	KRONER	CHECKED BY	CJR	3-22-91	DRAWING NUMBER 304923-A26
	3-20-91	APPROVED BY	TDK	3-22-91	



Source: Jefferson County Remedy Lands
Semi-Annual Report Summer, 1991

Figure 2-4
Map of North Area Tilled Strips of Remedy Land Showing Soil Sample Location Sample Number and Results of Pu 239, 240 Analysis

significantly reducing the amount of land requiring reseeding. The January 1991 report proposes the following actions to facilitate revegetation of the remaining acreage:

- Weed control
- Prairie dog suppression
- Change of seed mixture.

Irrigation of the revegetated areas, which was proposed in the 1990 Remedy Status Report (EG&G, 1990c), is not being considered because of water quality issues related to using RFP water for irrigation, and concerns over surface runoff transport of contaminants from the remedy acreage.

Because soil samples collected from the remedy acreage in 1986 and 1987 (Table 2-1) do not meet current quality assurance protocols, soil samples were collected again in January 1991 from both tilled and untilled Jefferson County acreage to confirm the soil plutonium concentrations on these lands. These samples were analyzed for plutonium and americium. The results of the 1991 soil sampling are presented on Figures 2-4 through 2-7.

2.1.3 Other Relevant Historical Studies for IHSS 199

In 1982, a study was performed by the RFP to investigate beryllium in soils. During this study, 243 samples were analyzed for beryllium. The study concluded that no surficial soils near the RFP contained detectable beryllium contamination, and that no atmospheric transport of beryllium was indicated (Barrick, 1982).

As mentioned in the ongoing RFP monitoring presented in Section 1.3.8, soil sampling is conducted annually by the RFP. Results for plutonium samples collected from 1984 through 1990 are summarized in Figure 2-8.

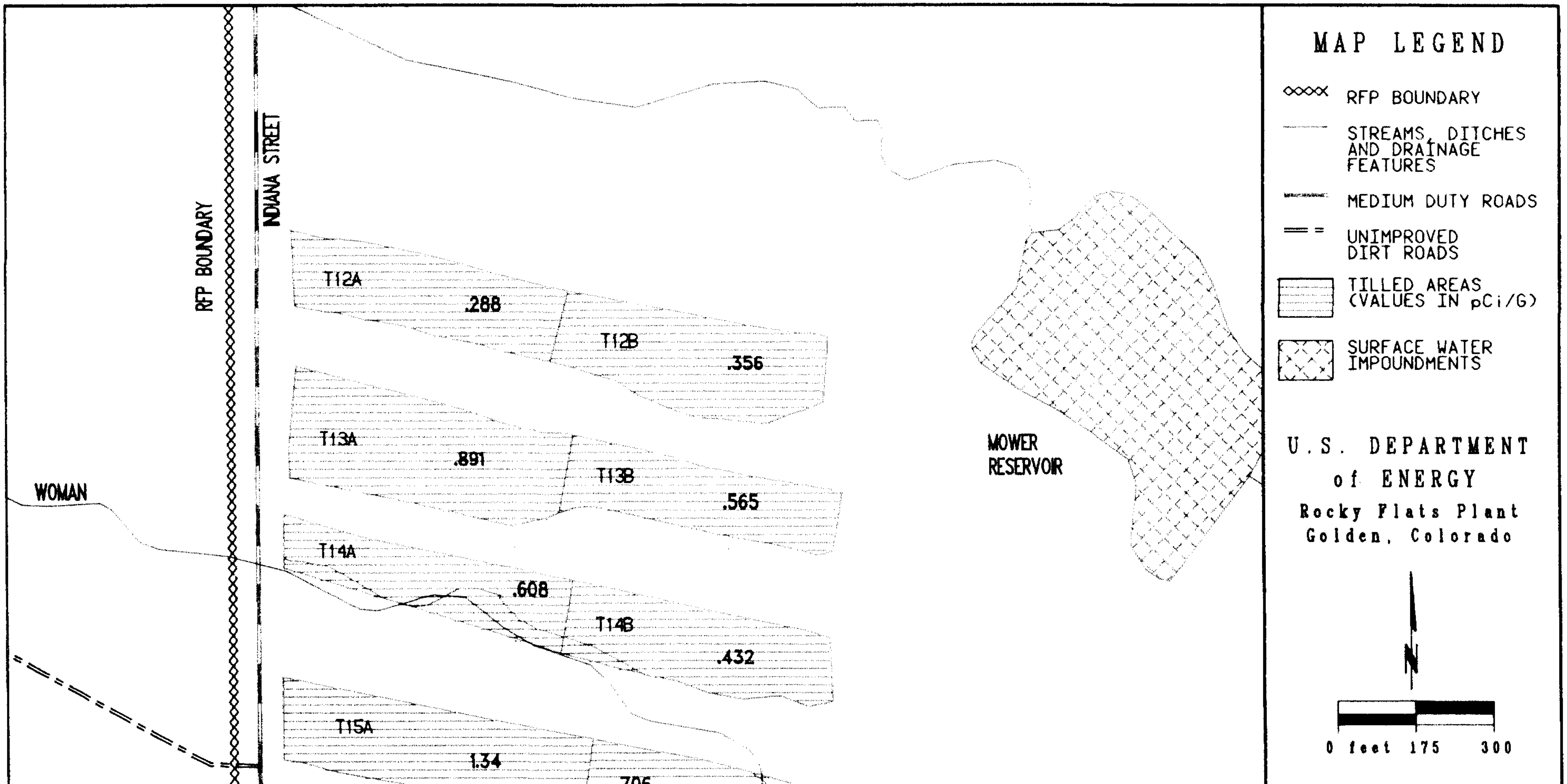
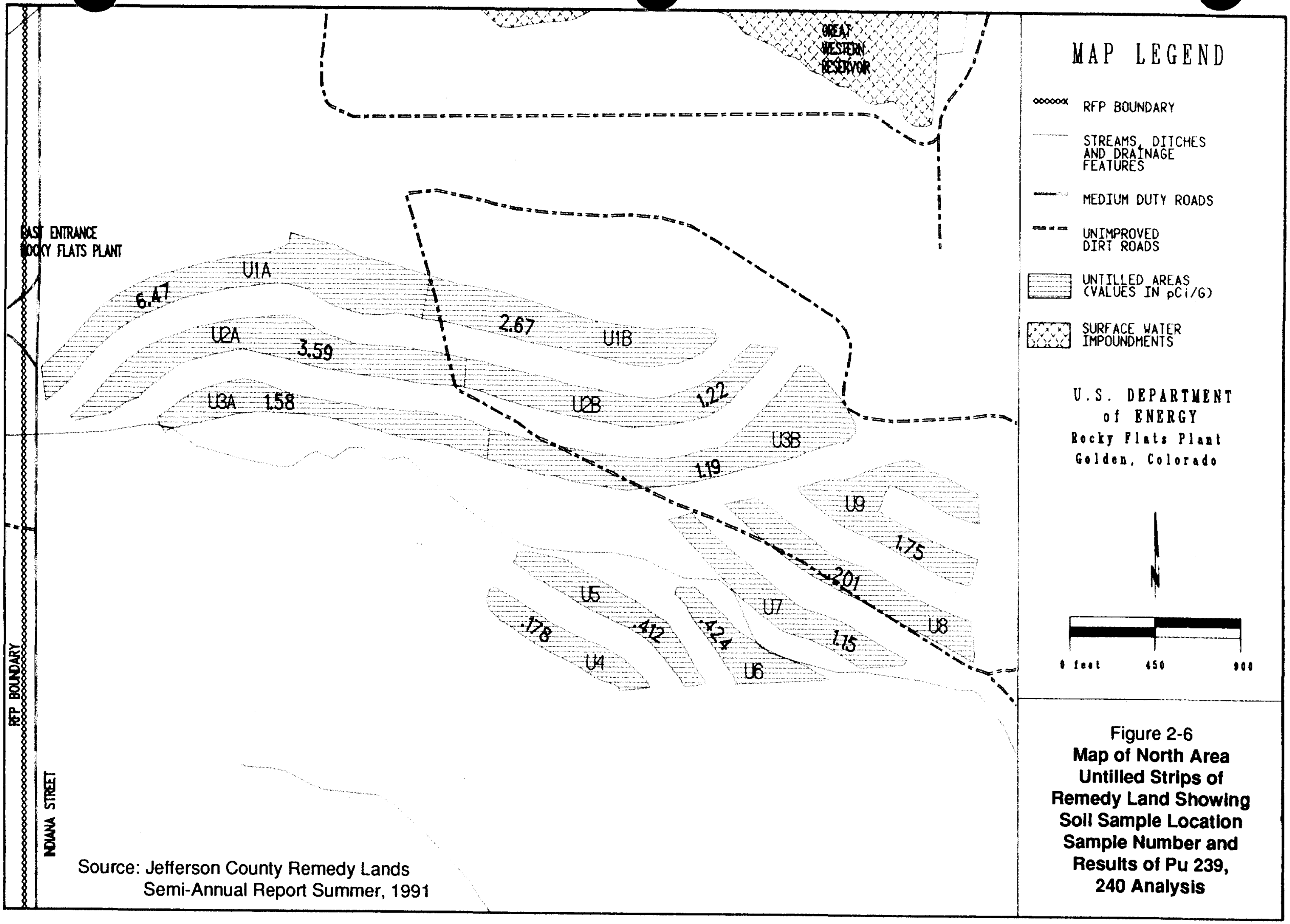


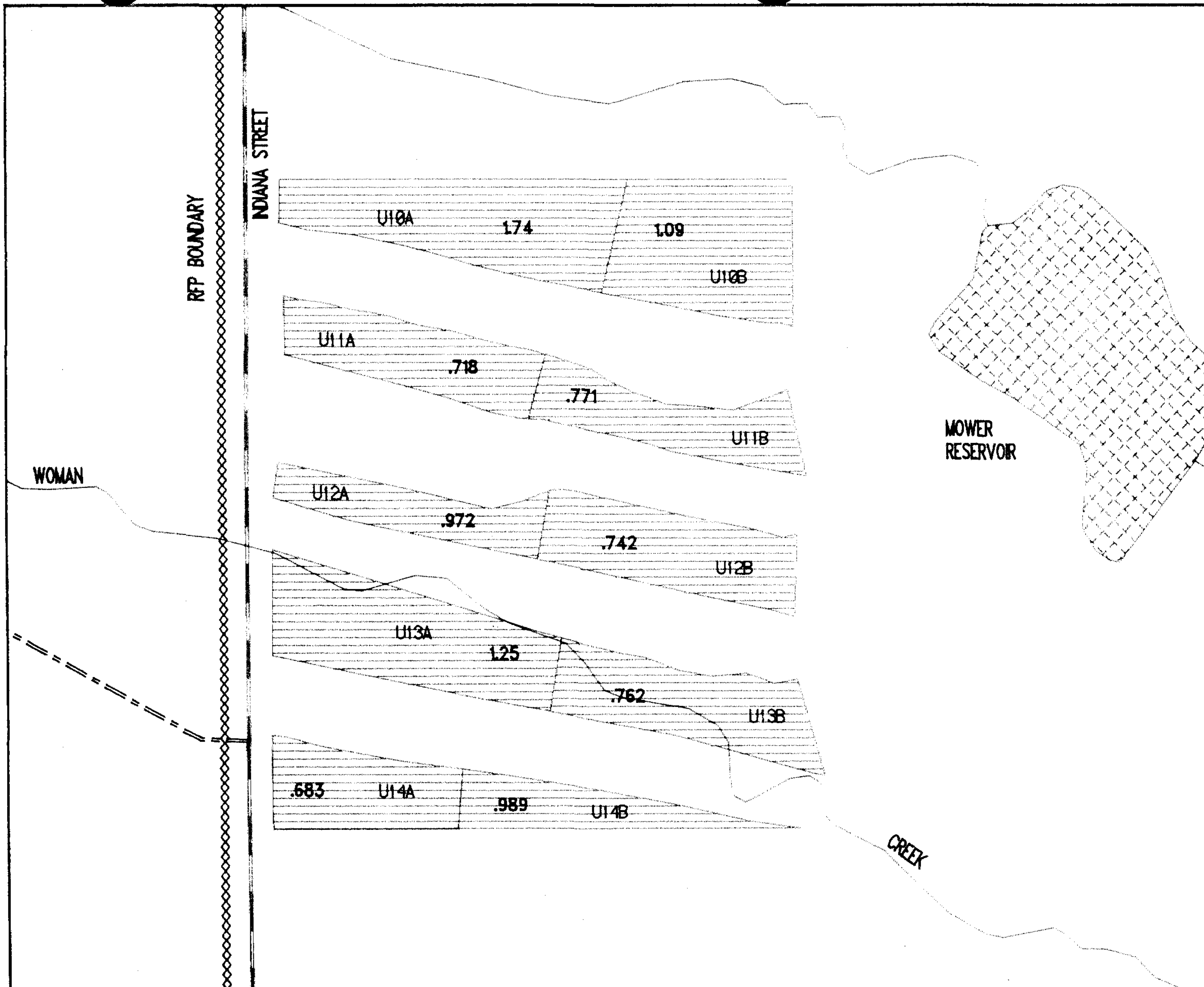
Figure 2-5
Map of South Area Tilled Strips of Remedy Land Showing Soil Sample Location Sample Number and Results of Pu 239, 240 Analysis

Source: Jefferson County Remedy Lands
Semi-Annual Report Summer, 1991



Source: Jefferson County Remedy Lands
Semi-Annual Report Summer, 1991

Figure 2-6
Map of North Area Untilled Strips of Remedy Land Showing Soil Sample Location Sample Number and Results of Pu 239, 240 Analysis



Source: Jefferson County Remedy Lands
Semi-Annual Report Summer, 1991

Figure 2-7
Map of South Area Untilled Strips of Remedy Land Showing Soil Sample Location, Sample Number, and Results of Pu 239, 240 Analysis

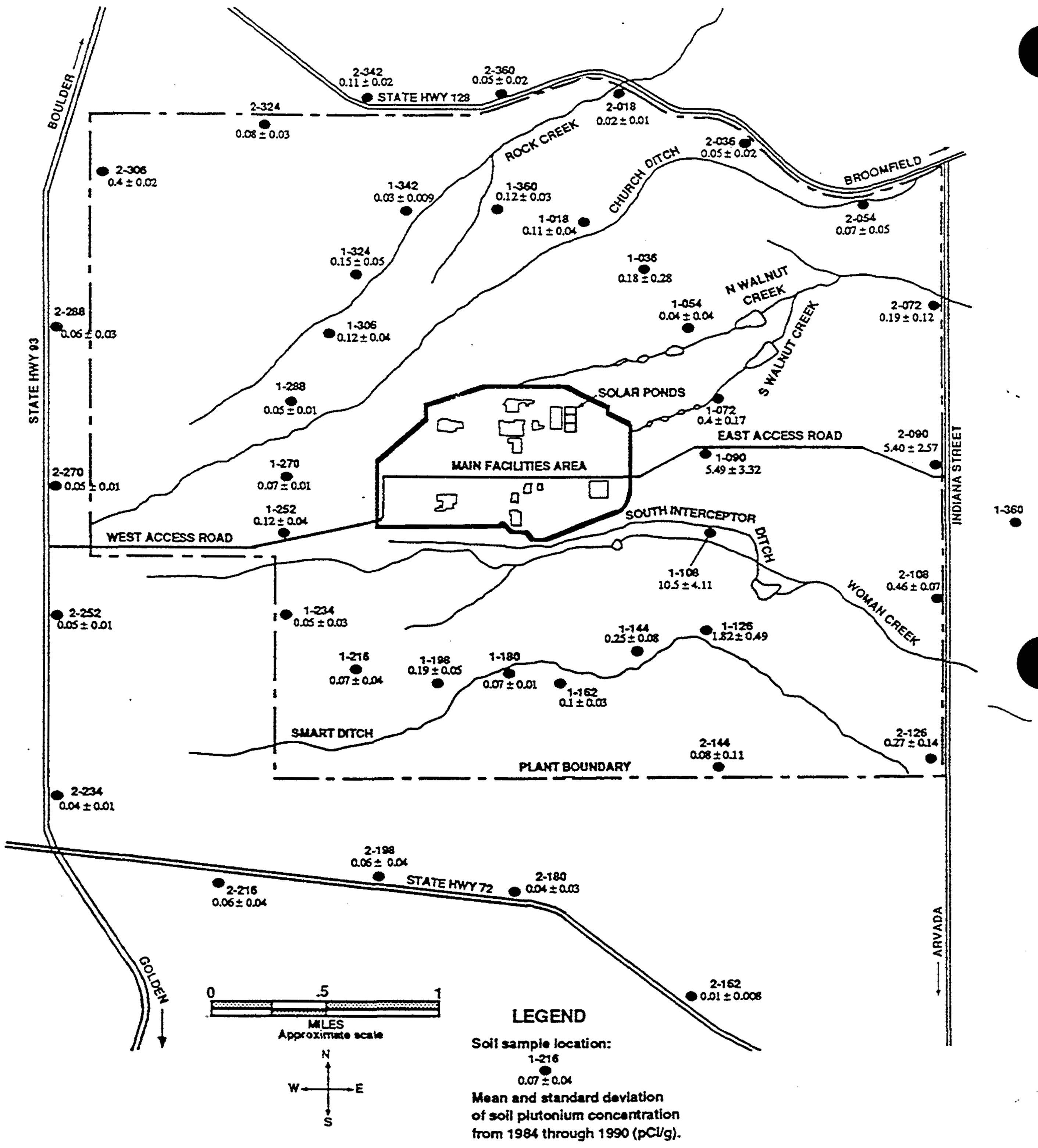


Figure 2-8 Soil Sampling Locations at the RFP in 1990

Source: EG&G Rocky Flats ("Rocky Flats Plant Annual Environmental Monitoring Report, 1990")

2.1.4 IHSS 199 Conditions

The following sections address the soils, hydrology, and biota of IHSS 199. Because IHSS 199 boundaries have not been conclusively defined, and because site conditions at the IHSS 199 remedy acreage adjoining the RFP have been studied in detail, the following descriptions focus primarily upon studies of the remedy acreage.

2.1.4.1 Soils

A general description of the soils in the IHSS 199 areas east and south of the RFP is provided in the SCS Soil Survey of the Golden Area, Colorado (SCS, 1980). According to this survey, soils in the area are characteristically well drained, clayey and loamy soils on high terraces, hill slopes, and fans. The primary soil type in this area is mapped by the SCS as Nunn-Denver complex, comprised of approximately 45 percent Nunn, 25 percent Denver, and 30 percent other soil types and Urban land. Nunn and Denver soils are deep and well drained, and form from clayey material derived predominantly from mudstone and shale. The surface layer is a clay loam. The Nunn subsoil is a clay loam to a depth of 60 in (152 cm), while the Denver subsoil is clay to the same depth. The SCS also notes that Primen and Leyden soil units occur within the area on gravelly and cobbly hill slopes.

Soil characteristics in the IHSS 199 remedy acreage were considered by the SCS in providing erosion control and revegetation recommendations for the remedy (SCS, 1985). The soils were characterized as Denver-Kutch-Midway clay loams, estimated at 50 percent Denver, 30 percent Kutch, and 20 percent Midway, with Denver and Kutch soils on hill slopes and Midway soils on ridge crests. Establishment and maintenance of grasses and other vegetation in the Denver-Kutch-Midway soil complex are restricted by the slope, the clay loam surface layer and clayey subsoil, and, on the Midway soil, shallow depth to bedrock. The complex is described as generally unsuitable for cultivation due to the high risk of erosion. When attempting to vegetate the soil, supplemental irrigation at planting time and during dry periods is recommended (SCS, 1980).

The SCS estimated annual soil loss rates because of water and wind erosion for northeast-facing slopes at the remedy acreage under worst-case conditions (such as bare soil) and under remedial activity conditions (such as tilled, with a cover crop). Total annual loss through water and wind erosion may range from 93 to 143 tons per ac (209 to 321 metric tons per ha) under worst-case conditions. This loss would be reduced to 13 to 22 tons per ac (29 to 49 metric tons per ha) under remediation without using protective mulch between plowing and establishment of a cover crop. If such a mulch was used, the loss due to erosion is predicted to be 1 to 3 tons per ac per year (2.2 to 6.7 metric tons per ha per year), almost exclusively attributable to water erosion. Gullying, which might increase the total loss in the worst-case scenario, was identified as a likely problem if the land was not adequately protected during remedial activities (SCS, 1985).

Soil conditions may have changed on the remedy acreage as a result of court-ordered remediation. In particular, the following changes may have occurred as a result of tilling:

- Increase in erosion potential due to vegetation loss
- Mixing of soil horizons and redistribution of rock fragments
- Loss of plant nutrients, particularly nitrogen, through leaching
- Loss of organic matter through increased oxidation
- Loss of soil structure.

It should be noted that water erosion does not appear to be a common or significant problem on undisturbed soil surfaces in and around the IHSS 199 remedy acreage. It is believed, therefore, that successful revegetation of the remedy acreage will greatly reduce the contribution of surface runoff and erosion to plutonium transport at IHSS 199.

Revegetation of IHSS 199 remedy acreage has been hampered by abundant cobbles in the soil, which were brought to the surface by tilling. Surface accumulations of cobbles are estimated to cover some 30 percent of the 120 tilled ac, and in some areas cover nearly 90 percent of the surface (EG&G, 1990c; EG&G, 1991b). An inactive gravel pit is located in the northeastern corner of the Section 7 remedy acreage. It can be inferred from these observations that the rock fragment content of some portions of the remedy acreage soil is appreciable, perhaps 15 to 20 percent or more by volume.

2.1.4.2 Surface Water

The City of Broomfield remedy acreage in Section 7 abuts Great Western Reservoir to the north. The Jefferson County remedy acreage in Section 18 is immediately west of Mower Reservoir (IHSS 202). Mower Reservoir is fed by a diversion from Woman Creek, which flows from the southern part of the RFP. Outflow from Mower Reservoir discharges to the east, eventually entering Standley Lake. Woman Creek itself traverses the southern end of the Jefferson County remedy acreage before discharging to Standley Lake (IHSS 201).

Existing slopes at and near the remedy acreage are 2 to 15 percent, generally to the east. Slopes to the west also are present (SCS, 1985). Most of the remedy acreage drains into two ephemeral channels, which flow southeast from the acreage into Standley Lake (IHSS 201) (USGS, 1980). Portions of the northernmost City of Broomfield remedy acreage in Section 7 drain north into Great Western Reservoir (IHSS 200). The southernmost Section 18 remedy acreage drains directly into Woman Creek.

The frequency and amount of surface runoff depend upon several factors, including soil infiltration capacity, surface vegetation, and slope. The clay loam soils at IHSS 199 are assumed to have relatively low infiltration capacity because of clay content, except where fractures may have significantly increased vertical permeability. Vegetation cover, addressed in more detail in Subsection 2.1.3.4, is somewhat sparse, consisting mostly of native grasses and weeds. Parts of the 120 ac of remedy acreage tilled during 1986 to 1987 contain adequate to marginal ground cover of perennial grasses and weeds. Some surfaces of the remedy acreage are poorly vegetated because of prairie dog colonies and cobbles brought to the surface by tilling. Application of mulch on this surface (see Subsection 2.1.2.2.2) would reduce the likelihood of surface runoff.

2.1.4.3 Groundwater

Currently, there are no dedicated groundwater monitoring wells outside of the RFP eastern boundary. Numerous privately-owned water wells, however, have been drilled just east of the RFP. Limited information was obtained from drilling and filing records held by the Colorado Division of Water Resources. These records suggest that the thickness of surficial deposits ranges from 15 to 50 ft (4.6 to 15 m) and averages approximately 25 ft (7.6 m) near the remedy acreage. Surficial deposits typically are described in the well records as clay, sandy clay, or clay with gravel and boulders, locally capped by 5 or 6 feet of topsoil. The underlying bedrock is described in the well records as alternating layers of shale and sandstone, which is assumed to be a very generalized description of the Arapahoe Formation. Most of the wells studied were completed in sandstones at depths ranging from 35 to 275 ft (10.7 to 84 m). Static water levels averaged 10 to 50 ft (3.0 to 15 m) higher than the screened interval, indicating moderate pressure head in the sandstones. The static water level was 20 ft (6.1 m) in one well completed in the shallow aquifer (alluvium) in the southwest corner of Section 6, just north of the IHSS 199 remedy acreage (DWR, 1990).

2.1.4.4 Biota

Much of the land surface in OU 3 has been converted to land uses that no longer have native species or natural ecosystems. Disturbed land surfaces include cultivation for agricultural crops, roads and right-of-way, development for housing and commerce, and canals and reservoirs for water control and storage. Much of this land surface has secondary growth of vegetation, including managed lawns and grasses. The vegetation tends to be weedy and the species present are those that invade after disturbance. Grazing is common on grasslands except the open space property of Jefferson County and the City of Broomfield.

IHSS 199 vegetation consists of native grasses and weeds, with various shrubs and small trees along drainages. Native grasses common to the area include western wheatgrass, green needlegrass, blue grama, and sideoats grama (SCS, 1980). Lands that have been tilled and seeded as part of remediation have been dominated in the early stages of regrowth by weeds, including

Canadian, Russian and musk thistles, mustards, bindweed, and cheatgrass (Rockwell, 1989c). Although these weeds compete with the grasses planted at the remedy acreage, they provide fair but unreliable stabilization of soils. As of late 1990, planted grasses have become established on approximately 50 percent of the northern (Section 7) remedy acreage and provide excellent soil stabilization. Planted grasses were characterized as marginally established on 15 to 20 percent of the northern acreage and unestablished on 30 to 35 percent of the acreage, owing primarily to surface cobbles and competition from weeds (EG&G, 1991c). The seed mix mandated by the Settlement Agreement includes western wheatgrass, sideoats grama, pubescent wheatgrass, and smooth brome (SCS, 1985). Winter wheat and sorghum also have been planted on these lands as winter cover to help prevent soil erosion during remediation.

Fauna indigenous to IHSS 199 are believed to be similar to those described in Subsection 1.3.5 for the RFP area as a whole. It has been noted that a significant prairie dog population has become established on the remedy acreage (EG&G, 1990c; EG&G, 1991c). The USFWS has indicated that there are two endangered species of interest in the RFP–the bald eagle and the black-footed ferret (Rockwell International, 1988c). Prairie dog towns provide the food source and habitat for ferrets. Bald eagles are common winter visitors in the areas near the reservoirs.

2.1.5 Nature of Contamination

Numerous studies have attempted to define the presence and extent of contamination at IHSS 199 as a result of RFP releases, and to identify prospective RFP source(s) of the contaminants. As mentioned in Subsection 2.1.1, these past studies have focused almost exclusively on airborne plutonium releases from the RFP. The OU 3 RFI/RI will investigate contaminants other than plutonium, as reflected in the Field Sampling Plan presented in Section 6.0 of this document.

2.1.5.1 RFP Contamination Sources

Krey and Hardy (1970) sought, among other goals, to identify onsite sources of the plutonium found in offsite soils. These investigators focused on four sources that might conceivably have resulted in offsite contamination: (1) a September 11, 1957 fire in Building 771 (Dow, 1973); (2) a May 11, 1969 fire in Building 776 (USAEC, 1969; CCEI, 1970); (3) leaking drums of plutonium-contaminated lathe coolant at the 903 Pad, a drum storage area in the southeastern part of the RFP main production area; and, (4) chronic low-level stack effluent. Based on the particle size of the contaminated soil fraction, meteorological data, and RFP monitoring records, the Krey and Hardy investigation concluded that the great majority of the plutonium at IHSS 199 originated as windborne particulates from the 903 Pad, and largely dismissed the contributions of the 1957 and 1969 fires and chronic stack emissions. Contamination at the 903 Pad resulted from 55-gallon drums of plutonium-contaminated lathe coolant which corroded and leaked over a 10-year period starting in 1958. The 903 Pad was capped with asphalt in November 1969 effectively eliminating it as a direct source of contamination to IHSS 199. Numerous other investigations focusing on plutonium in offsite soils since the Krey and Hardy study have reinforced the conclusion that the 903 Pad was the primary source of offsite soil plutonium contamination from the RFP (Dow, 1971; Dow, 1972; CDH, 1977; Rockwell, 1979a; Rockwell, 1979b).

As discussed in Subsection 1.3.7, contaminants other than plutonium have been detected in the environment as a result of RFP releases. Available information on RFP IHSSs suggests that some of these other contaminants could potentially have impacted IHSS 199 through airborne transport from the RFP. Possible sources include the onsite burning of wastes, including waste oils contaminated with trace amounts of uranium (IHSSs 128, 153, 154, and 171). A fire that breached the exhaust filters of a beryllium-machining building, possibly releasing airborne beryllium to the environment, has also been documented but has not resulted in the designation of an IHSS. A less plausible potential source is wind stripping of waste water from the solar evaporation ponds (IHSS 101; see Figure 2-1), incidences of which are documented in records from the Dow Chemical Waste Disposal Coordination Group. Water from the solar ponds would have possibly contained trace amounts of radionuclides, nonradioactive metals, and inorganic ions. Knowledge of the fate and mobility of these potential contaminants in air and surface soils is critical in determining whether they could reasonably have impacted IHSS 199 and, if so, whether they still exist at the site today. Contaminant fate and mobility are addressed in the conceptual model for offsite surface soils (Subsection 2.5.1). Available information from onsite and offsite RFP environmental monitoring

(Subsection 1.3.8) and RFP OU investigations are used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6.2).

It is possible that onsite soils contaminated by the 903 Pad could in turn generate windborne particulates, which might impact IHSS 199, as could any abnormal airborne emission from the RFP, including those generated by soil remediation and similar activities at onsite RFP OUs. Results from offsite air monitoring stations (Rockwell, 1989a) suggest that IHSS 199 has not been measurably impacted by airborne emissions from the RFP since the offsite air monitoring system was established in 1975. It is reasonable to expect that any future RFP emission potentially impacting IHSS 199 will also impact onsite soils and ambient air, and that the contamination will be detected through routine onsite air and soil monitoring (Subsections 1.3.7.1 and 1.3.7.3).

2.1.5.2 IHSS 199 Contamination

In an attempt to delineate offsite plutonium contamination around the RFP, Krey and Hardy (1970) established contours in millicuries per square kilometer (mCi/km^2), for plutonium in soil around the RFP, based upon analytical results from 33 soil samples collected from locations up to 40 mi (64 km) from the plant (Figure 2-9). Dow (1971) based similar contours (Figure 2-10) on results from 135 soil samples. Dow's 1972 Rocky Flats Annual Environmental Monitoring Report (Dow et al., 1971 to date) included soil plutonium contours, in microcuries per square meter (uCi/m^2), based on over 300 soil samples (Figure 2-11). The differences in the results of these studies help to illustrate the inherent difficulty in drawing conclusions about IHSS 199 contamination based upon existing data. Results, and hence conclusions, vary widely depending upon sampling methods, analytical methods and uncertainty, definition of "background" concentrations, and units of measurement. Most of the data collected since 1972 have focused specifically on characterizing the lawsuit acreage rather than defining IHSS 199 as a whole (Rockwell, 1979a; Rockwell, 1979b; Rockwell, 1985a; Rockwell, 1985b; Rockwell, 1987a; Rockwell, 1987b) because the investigations preceded the designation of the offsite soils as IHSS 199. Very few data exist for contaminants other than plutonium, which could affect offsite soils as a result of RFP releases.

In short, the extent of offsite soil contamination as a result of RFP releases, which will delineate the boundaries of IHSS 199, has not been conclusively defined. Studies conducted to date, however, do point to the following limitations:

- IHSS 199 is most likely limited to areas downwind of the RFP, namely to the northeast, east, and southeast of the plant.

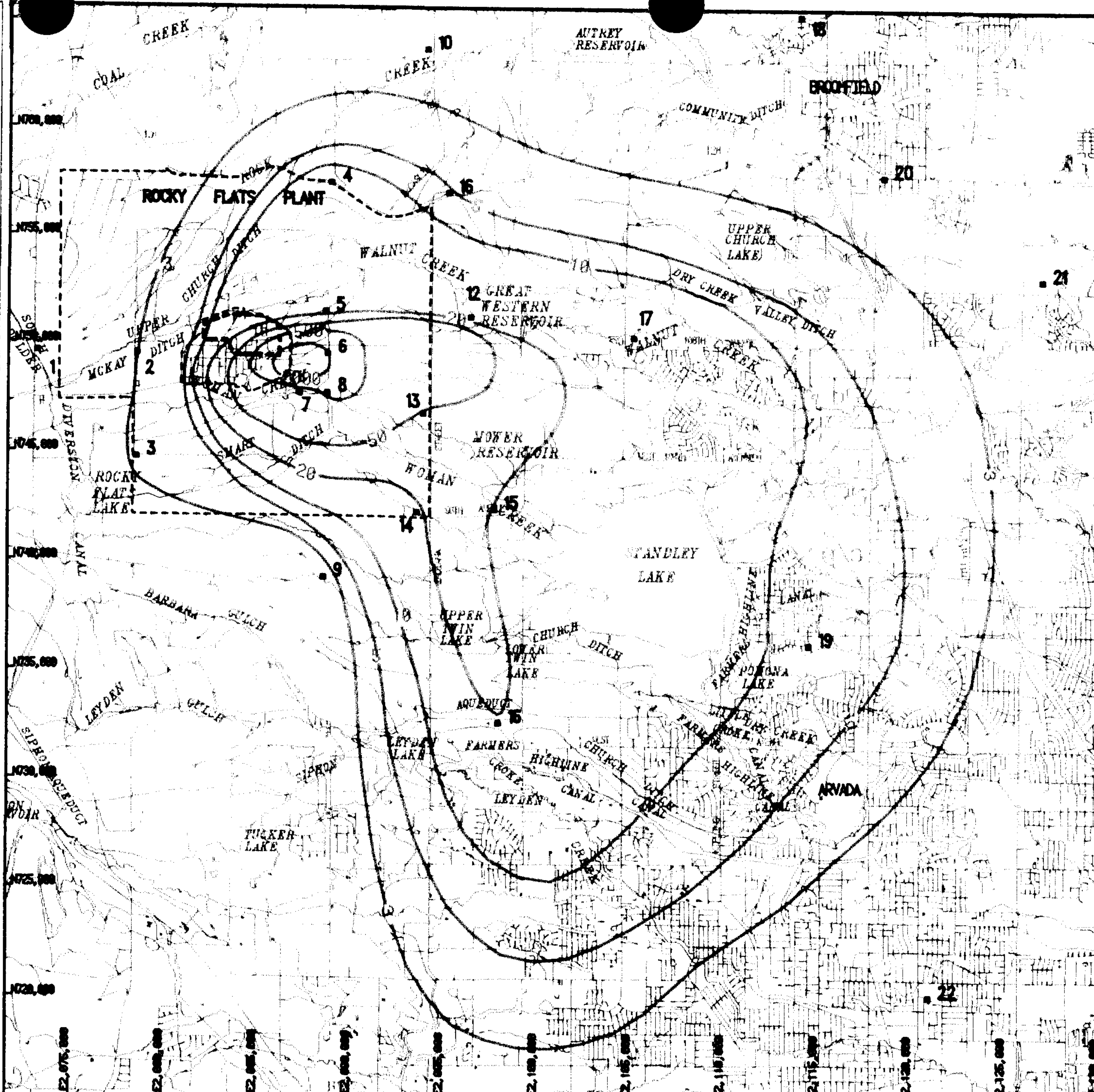
- The 350 ac of lawsuit acreage targeted for remediation were shown to have the highest concentrations of plutonium in soil of all lawsuit acreage, which adjoined most of the eastern and southern boundaries of the RFP (Rockwell, 1979b). "Hot spots" may occur that were not detected through lawsuit acreage sampling; however, because other IHSS 199 lands downwind of the RFP are further from the plant than the remedy acreage, it is reasonable to expect that these lands contain lower concentrations of plutonium than the remedy acreage.

- The most likely pathways of plutonium migration from IHSS 199 are wind and water erosion of surface soil (SCS, 1985).

Existing IHSS 199 soil plutonium data are summarized in Table 2-2.

Very limited data exist for contaminants other than plutonium, which could affect offsite soils as a result of RFP releases. In 1976 and 1977, the RFP tested lawsuit acreage soils for isotopes of americium, cesium, thorium, neptunium, cerium, radium, and potassium in addition to plutonium. The sampling program also included five sites remote from the RFP in order to determine representative background concentrations (Rockwell, 1979a; Rockwell, 1979b). The Rockwell International Disclosure to the City of Broomfield following the lawsuit (Rockwell, 1985a) based the following conclusion on the results of the 1976 to 1977 sampling:

> "Analysis of 25 soil samples from plaintiffs' lands and samples from each of the five background locations used in the testing program show that with respect to



MAP LEGEND

- - - - RFP BOUNDARY AND PSZ

——— CONTOUR VALUES IN mCi per km2

■ NUMBERED SAMPLING SITES

Figure 2-9
Plutonium-239 Contours in the Vicinity of the Rocky Flats Plant Krey and Hardy (1970)

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	11/04/91	APPROVED BY	ALL	11-25-91		

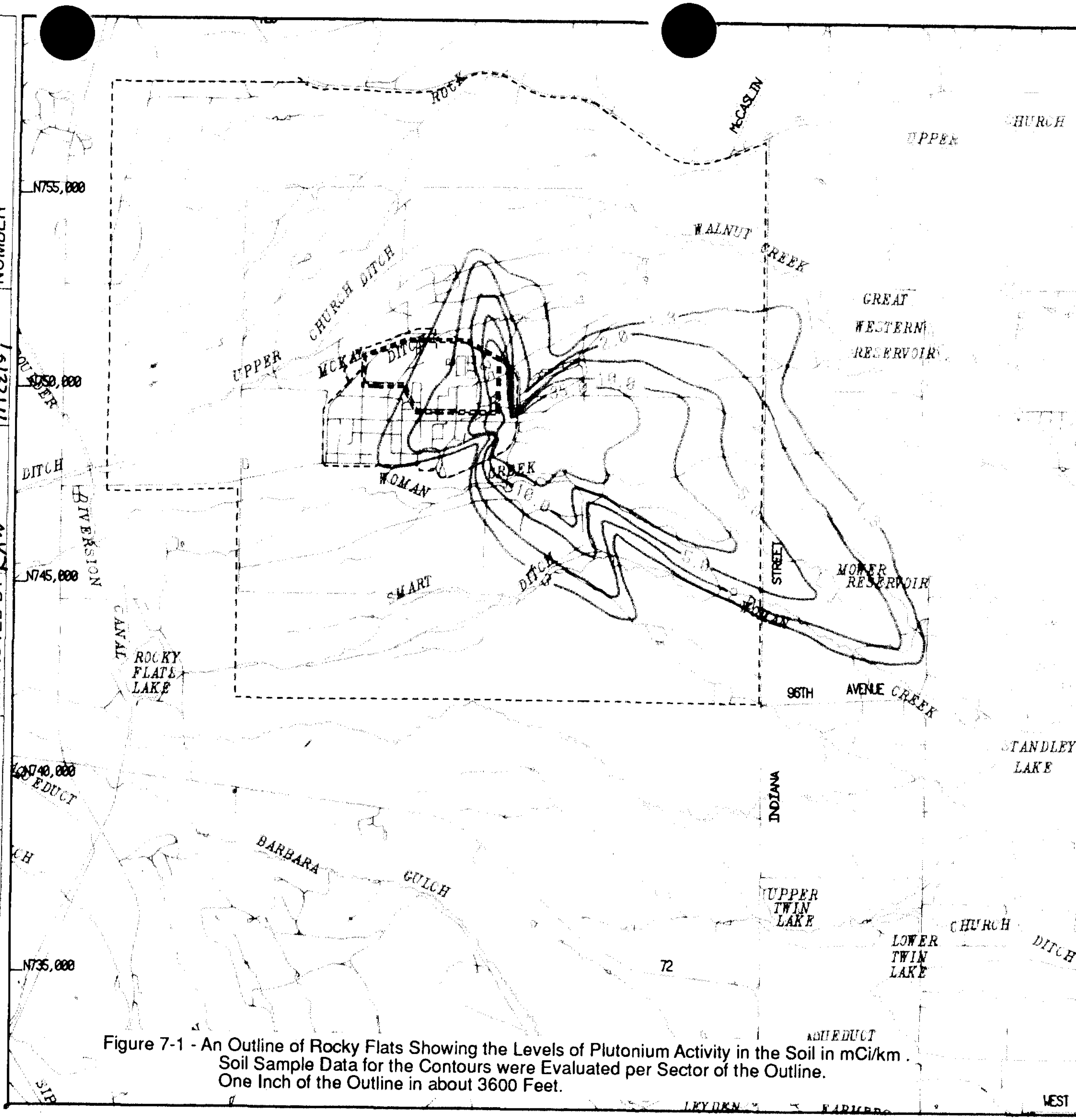


Figure 7-1 - An Outline of Rocky Flats Showing the Levels of Plutonium Activity in the Soil in mCi/km . Soil Sample Data for the Contours were Evaluated per Sector of the Outline. One Inch of the Outline in about 3600 Feet.

MAP LEGEND

RFP BOUNDARY AND PSZ

CONTOUR VALUES IN pCi/g

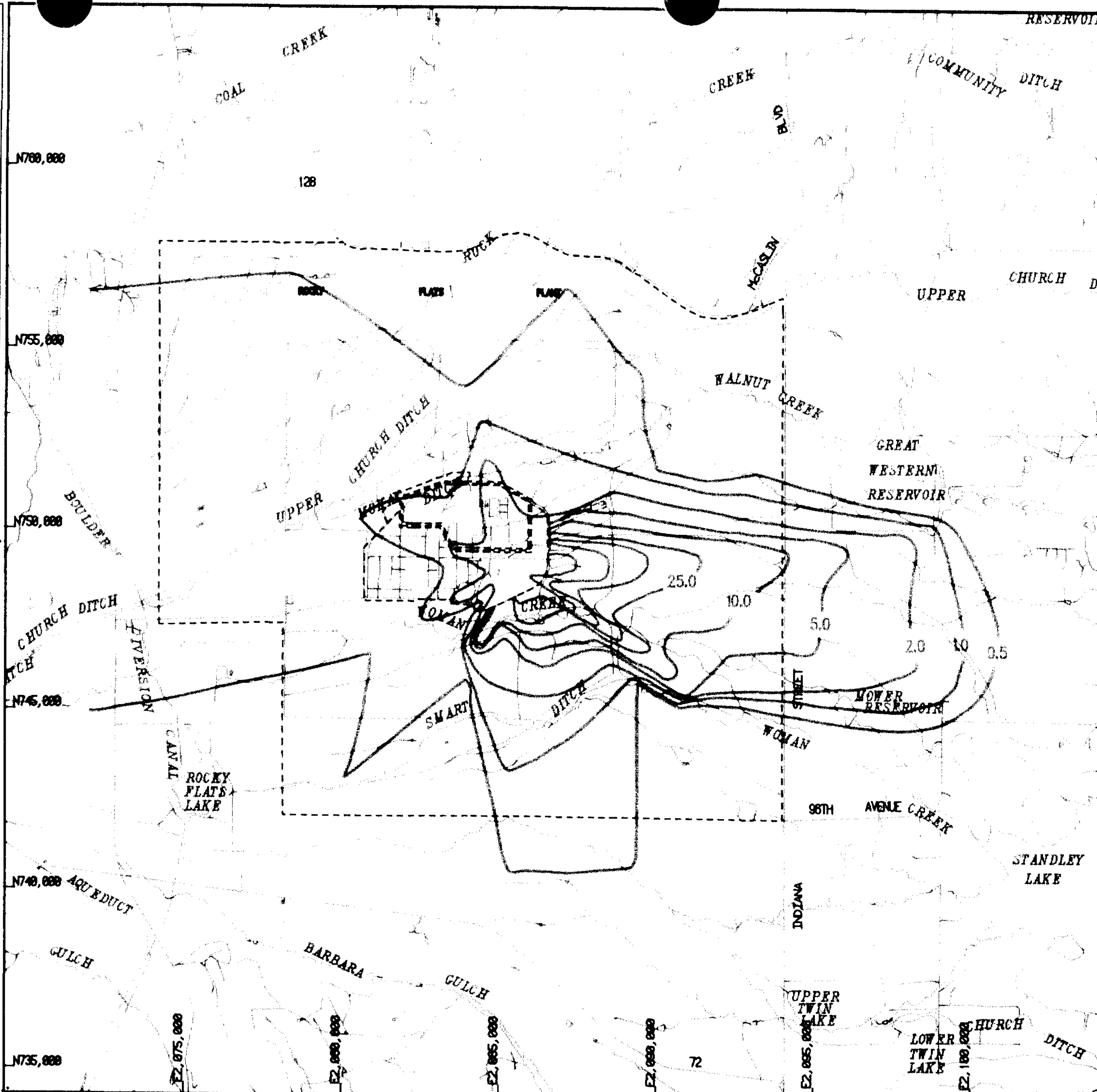
SOURCE: FIGURE 7-1, J.R. SEED et al., DOW CHEMICAL COMPANY, "COMMITTEE EVALUATION OF PLUTONIUM LEVELS IN SOIL WITHIN AND SURROUNDING USAEC INSTALLATION AT ROCKY FLATS, CO" JULY 9, 1971.

N

0 feet 2000 4000

Figure 2-10
Plutonium Contours Around Rocky Flats Plant DOW (1971)

DRAWN BY	Douville 10/21/91	CHECKED BY / APPROVED BY	PDS / KRW	11/21/91 / 11/22/91	DRAWING NUMBER RF1013



MAP LEGEND

- - - - RFP BOUNDARY AND PSZ

——— CONTOUR VALUES IN pCi/g

(Interior Contours Removed from Figure for Clarity)

SOURCE: DOW CHEMICAL COMPANY, "ANNUAL ENVIRONMENTAL REPORT" ROCKY FLATS PLANT, JANUARY-DECEMBER 1972.

N

0 FEET 2400 4800

Figure 2-11
Plutonium-239 Contours in the Vicinity of the Rocky Flats Plant Krey and Hardy

DRAWN BY	Douville 10/21/91	CHECKED BY	PBS	11/21/91	DRAWING NUMBER	RF1014
		APPROVED BY	KbW	11/22/91		

TABLE 2-2

SUMMARY OF IHSS 199 HISTORICAL PLUTONIUM IN SOIL DATA

Data Source	Range (pCi/g unless otherwise noted)	Average (pCi/g unless otherwise noted)	No. of Data Points	Comments
"Plutonium in Soil Around the Rocky Flats Plant," by P.W. Krey and E.P. Hardy, 1 August 1970	0.0007-0.963	0.085	27	1,2,3
"Committee Evaluation of Plutonium Levels in Soil Within and Surrounding USAEC Installation at Rocky Flats, Colorado." by J.R. Seed et al., 9 July 1971	0.045-139.7	5.0	123	1, 2, 4
"Soil Sampling East of Indiana Avenue," by R.W. Loser and R.L. Tibbals, 29 November 1972	2.7-594 mCi/km^2	99.3 mCi/km^2	14	1, 5
"Results of Special Soil Samples Collected Adjacent to the Rocky Flats Plant Site," by C.T. Illsley, 7 September 1977 (revised 30 November 1979)	0.01-1.48	0.207	20	1, 2
"Radioactive Soil Contamination (Cesium-137 and Plutonium) in the Environment Near the Rocky Flats Nuclear Weapons Plant," by CDH, September 1977	Data contained in this report are included in the 1970-1989 CDH report below			
"Plutonium Concentrations in Soil on Lands Adjacent to the Rocky Flats Plant," by C.T. Illsley and M.W. Hume, 16 March 1979	0.009-3.42	0.19	160	1, 2
"Disclosure to the City of Broomfield," by Rockwell International, 22 January 1985	0.06-7.7	N/A	N/A	1, 2, 6
"Soil Sample Collection and Analysis for Plutonium on Lands Adjacent to Great Western, Reservoir for the City of Broomfield," by C.T. Illsley, 15 January 1987	0.04-3.8	1.2	15	1, 2
"Remedial Action Program on Jefferson County Open Space Land in Section 7, T2S, R69W, South of Great Western Reservoir," by C.T. Illsley, 15 October 1987	1977 0.06-7.7	1.55	22	1, 7
	1985 0.03-5.6	1.70	24	
"Rocky Flats Surface Soil Survey, 1970-1989," by CDH, February 1990	1970 0.01-11.0	1.2	13	1, 2, 4
	1971 0.03-30.1	2.6	13	1, 2, 4

TABLE 2-2

SUMMARY OF IHSS 199 HISTORICAL PLUTONIUM IN SOIL DATA (Concluded)

Data Source	Range (pCi/g unless otherwise noted)	Average (pCi/g unless otherwise noted)	No. of Data Points	Comments
	1972 0.02-25.1	2.1	13	1, 2, 4
	1973 0.03-0.38	0.12	5	1, 2
	1974 0.02-12.7	1.2	13	1, 2, 4
	1975 0.01-4.30	1.1	10	1, 2
	1976 0.02-3.50	0.4	13	1, 2
	1977 0.03-4.20	0.5	13	1, 2
	1978 0.03-0.25	0.09	6	1, 2
	1980 0.01-3.1	0.3	13	1, 2
	1981 0.18-2.2	0.3	12	1, 2
	1986 0.01-1.5	0.2	13	1, 2

Notes:

[1] Data do not meet EPA useability criteria for risk assessment (EPA, 1990b).
[2] Values originally expressed in dpm/g; converted to pCi/g using a 0.45 multiplier.
[3] Included multiple analyses by various laboratories; some data points have multiple values.
[4] Some data points are within the present RFP boundary; sample locations are not defined clearly enough to separate these from data points outside the RFP boundary.
[5] Document lacks adequate description of sampling and analytical methodology and contains inconsistent definition of sample locations. Because conversion of mCi/km^2 to pCi/g requires detailed knowledge of methodology and properties of the medium sampled, this conversion could not reliably be performed; however, reported values appear to be much higher than those recorded in other sampling programs in this area. Very low confidence in these values.
[6] Document presents high, low, and average values from Broomfield remedy acreage sampling between 1977-1985.
[7] 1977 data do not include Broomfield remedy acreage.

radionuclides other than plutonium and americium, the levels of these radionuclides on plaintiffs' lands are consistent with background levels."

As indicated in this passage, americium-241, a daughter product of plutonium-241 decay, was detected in IHSS 199 soils above the background concentrations recorded at the five remote sampling locations. However, neither Rockwell (1985a) nor Rockwell (1979b), which also refer to americium data from the 1976 to 1977 sampling program, provide the analytical results for americium. Poet and Martell (1972) measured americium-241 and strontium-90 concentrations in soil samples collected in 1969 from several locations around the RFP. This study calculated that americium contributed 3 to 15 percent as much alpha activity as did plutonium in the areas sampled, and estimated that the americium contribution to alpha activity would eventually approach that of plutonium as decay of plutonium-241 into americium-241 progressed. The RFP soil sampling program conducted by CDH (see Subsection 1.3.7.3) has periodically included analyses for cesium-137 and uranium. These limited efforts represent the only known characterization of radionuclides other than plutonium at IHSS 199. Possible contaminants other than radionuclides present in IHSS 199 soils as a result of RFP releases have not been characterized, with the exception of beryllium measurements in 1971 and 1989 under the CDH soil monitoring program (CDH, 1990a) and the RFP study in 1982 (Barrick, 1982).

Ongoing studies of RFP OU 2 will provide more detailed characterizations of soil contamination between the 903 Pad and the RFP eastern boundary. In addition, studies at OU 4, the solar evaporation ponds, will provide additional information on potential soil contamination from metals. Studies are also underway to define background concentrations in soil of potential RFP contaminants, including "background" plutonium and americium resulting from atmospheric testing of nuclear weapons. The relevance of these background concentrations to IHSS 199 will be addressed in future RFI/RI (i.e., data evaluations) activities. Cumulative depositions of plutonium because of nuclear testing on ground surfaces in the United States range from 0.001 to 0.003 uCi/m^2 (EPA, 1990a). Data on RFP climatology also are available (Subsection 1.3.2.1).

2.2 IHSS 200 (GREAT WESTERN RESERVOIR)

IHSS 200 encompasses Great Western Reservoir, offsite reaches of Walnut Creek (which formerly flowed into the reservoir from the RFP), and downstream surface water features possibly impacted by outflow from the reservoir (Figure 2-1). Portions of Walnut Creek within the boundaries of the RFP will be investigated as RFP OU 6 and are not included in IHSS 200.

2.2.1 Location and Description

Great Western Reservoir is located approximately 1.5 mi (2.4 km) east of the RFP's eastern boundary in Sections 6 and 7 of Township 2 South, Range 69 West (T2S, R69W) (Figure 2-1). The reservoir is owned by the City of Broomfield and is utilized solely for the city's municipal water supply. Great Western Reservoir and the surrounding area is fenced and posted to exclude public access (Broomfield, 1990).

Preconstruction information for the Great Western Reservoir site is not given in available references. The original reservoir was built in 1904 as an irrigation water supply. The dam has been enlarged on several occasions, most recently in 1958. The maximum height of the dam is 69 ft (21 m) (Hydro-Triad, 1981). The present reservoir volume is 3,250 acre-feet (401 hectare-meters). The bottom and sides of the reservoir are unlined, meaning that the reservoir may or may not be hydraulically connected to the groundwater system in the area (Miller, 1990).

2.2.2 IHSS Conditions

Although little site-specific information is available concerning the geology and groundwater hydrology of IHSS 200, plantwide hydrogeologic studies give an indication of conditions in the vicinity of the RFP. The following sections summarize relevant results of these studies and provide site-specific information, where available.

2.2.2.1 Geology and Groundwater Hydrology

The U.S. Army Corps of Engineers utilized data from two existing boreholes near Great Western Reservoir as part of a 1989 evaluation for a surface water interceptor system for the reservoir. In these boreholes, alluvium surficial deposits are underlain by Arapahoe Formation bedrock at depths of 5 and 16 ft (1.5 and 4.9 m). Bedrock consists of claystone with minor interbedded sandstone, and siltstone lenses, and dips slightly to the east (Corps of Engineers, 1989). The precise locations of these boreholes are not given in this document. The Arapahoe Formation averages 250 ft (76 m) in thickness in the RFP area, and is underlain by several hundred feet (approximately 100 m) of shale comprising the upper portion of the Laramie Formation (USGS, 1976). It is expected that a similar stratigraphic sequence underlies Great Western Reservoir.

A general description of groundwater hydrogeology in the vicinity of the RFP is given in Subsection 1.3.4.2. Specific groundwater hydrogeologic information for Great Western Reservoir is limited to drilling records from privately-owned water wells in the vicinity of the reservoir (DWR, 1990). The description of these records given in Subsection 2.1.3.3 for IHSS 199 also applies to Great Western Reservoir and the surrounding area.

2.2.2.2 Surface Water

Great Western Reservoir is fed primarily by Clear Creek via Lower Church Ditch (Figure 2-1). Until recently, the reservoir also received influent from the north and south branches of Walnut Creek, both of which flow from the RFP. The two branches merge into a single drainage within the RFP boundary (Figure 2-1). A chromic acid release at the RFP in 1989 prompted construction of a Walnut Creek diversion around Great Western Reservoir, known as the Broomfield Diversion Ditch (Figure 1-3). Surface water affected by the chromic acid was diverted around Great Western Reservoir and did not impact the reservoir (Dow et al., 1971 to date). Walnut Creek flow from the RFP is now treated and diverted south around Great Western Reservoir into the drainage below the reservoir outlet, where it combines with outflow from the reservoir. The Broomfield Diversion Ditch prevents surface water from the RFP from reaching Great Western Reservoir. Walnut Creek continues below Great Western Reservoir and eventually discharges to Big Dry Creek several miles downstream from the reservoir (USGS, 1980).

Within the RFP boundary, the North and South Walnut Creek drainages contain the A and B-series holding ponds, respectively. In North Walnut Creek, there are four ponds designated A-1, A-2, A-3 and A-4, from west to east (Figures 1-2 and 2-1). Ponds A-1 and A-2 are used only for spill control, and North Walnut Creek stream flow is diverted around them through an underground pipe. Pond A-3 receives North Walnut Creek stream flow and runoff from the northern portion of the RFP. Pond A-4 is utilized for surface water control and for overflow from Pond A-3 (DOE, 1988).

Five holding ponds located along South Walnut Creek are designated B-1, B-2, B-3, B-4 and B-5, from west to east (Figures 1-2 and 2-1). Ponds B-1 and B-2 are reserved for spill control. Pond B-3 receives treated effluent from the RFP sanitary sewage treatment plant. Ponds B-4 and B-5 receive surface runoff from the central part of the plant and routinely receive discharge from Pond B-3. Pond B-5 also collects overflow from Pond B-4 (DOE, 1988).

2.2.2.3 Biota

The aquatic biota in this reservoir consists of the common species of periphyton and macroinvertebrates, and a fairly large and stable population of fish since this reservoir is not assessable to the public. Rooted aquatic vegetation around this reservoir is minimal because of fluctuating shoreline and subsequent denudation by wave action. Studies to characterize the aquatic biota in this reservoir have not been undertaken.

2.2.3 Nature of Contamination

From the opening of the RFP in 1952 through approximately 1979, water containing decontaminated process and laundry effluent was discharged through the B-series ponds to South Walnut Creek (DOE, 1988; Dow, 1973). Cooling tower blowdown and treatment system steam condensate were discharged to the A-series ponds, which feed into North Walnut Creek. These effluents were discharged in accordance with internal guidelines (in particular, U.S. Atomic Energy Commission [USAEC] guidelines in the early history of the RFP), and, increasingly during the past two decades, with State and Federal pollution discharge regulations. The effluents contained metals, radionuclides, and inorganic ions (especially nitrate) within concentration limits considered acceptable at the time. Radionuclides and metals from these discharges accumulated in varying amounts in the sediments of the holding ponds, Walnut Creek, and Great Western Reservoir (DOE, 1980). The EPA (1975) concluded that historic releases of radioactive contaminants from the RFP to Great Western Reservoir resulted primarily from the following activities:

- Early operational practices at the plant (1950s and 1960s)
- Reconstruction of the holding ponds between 1970 to 1973, which resuspended pond sediments and released some of this material to Great Western Reservoir
- A 1973 tritium release from the RFP (Subsection 2.2.3.2)
- Airborne transfer of radionuclides (primarily plutonium).

Available data from onsite RFP OUs, particularly OU 6 (Walnut Creek Drainage), suggest that contaminants other than plutonium could conceivably have impacted Great Western Reservoir through surface water transport from the RFP. Leakage from the solar evaporation ponds (IHSS 101; see Figure 2-1) is known to have contaminated groundwater and surface water in the Walnut Creek drainage, primarily with nitrate and other inorganic ions. Inorganic ions, nonradioactive metals, VOCs, and uranium have been detected in the Walnut Creek holding ponds. Herbicides which have been applied in the past at various locations on the RFP have also been detected in RFP surface water. Knowledge of the fate and mobility of these potential contaminants in surface water and sediments is critical in determining whether they could reasonably have impacted Great Western Reservoir and, if so, whether they still exist at the site today. Contaminant fate and mobility are addressed in the conceptual model for reservoirs (Subsection 2.5.2). Available information from onsite and offsite RFP environmental monitoring (Subsection 1.3.8) and RFP OU investigations are used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6.2).

The following sections present chronological summaries of environmental studies conducted to date of IHSS 200. Analytical results from these studies are summarized in Table 2-3. The studies are incorporated by reference to the list of references in Section 12.0.

2.2.3.1 Reservoir and Drainage Sediments

The EPA conducted the first extensive sampling of bottom sediments in Great Western Reservoir in February and September 1970. The results indicated that a layer of sediment containing plutonium above the EPA estimated baseline (worldwide atmospheric fallout) level of $\leq$0.1 pCi/g, or 0.0037 Bq/g was present in the bottom of the reservoir. The thickness of the plutonium-bearing sediments was 2 in (5 cm) or more at all sampling locations. The highest concentrations of plutonium were detected in sediments in the Walnut Creek inlet area and the central section of the reservoir (leading to the dam inlet). The lowest concentrations were found in the south arm, the shoreline area between the south arm and the dam, and the western portion of the north arm (EPA, 1971; EPA, 1973).

The EPA resumed their investigation of plutonium in surface water sediments east of the RFP in September 1973. This phase of the study further documented plutonium concentrations in Great Western Reservoir. Sediment samples collected both by dredging and coring indicated that plutonium above expected baseline concentrations was present over almost the entire bottom of Great Western Reservoir as a result of releases from the RFP. The maximum plutonium concentration detected was 4.5 pCi/g (Table 2-3). The results confirmed the areal distribution of plutonium delineated by the 1970 study, except that the highest concentrations were found in the deepest areas of the reservoir rather than in the Walnut Creek inlet area. It was also observed that plutonium-239 concentrations in the uppermost sediment layer increased substantially in the three years between the studies. This increase was traced to an influx of sediment resuspended from the RFP holding ponds during pond reconstruction activities. This study also measured concentrations in Great

TABLE 2-3

GREAT WESTERN RESERVOIR PLUTONIUM ANALYTICAL DATA

Data Source	Range (pCi/g or l)	Average (pCi/g or l)	No. of Data Points
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Golden, Colorado, 1970," April 1971, by EPA (Appendix E, Document E-1)	Surf Sed[1]: 0.10-0.13	0.11	3
	Water: 0.03	0.03	1
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Colorado, 1970, Part II," December 1973, by EPA (Appendix E, Document E-2)	Surf Sed: 0.08-0.86	0.34	20
	Sed Core: 0.03-1.0	0.24	12
	Water: <0.02	<0.02	1
"Plutonium Levels in the Sediment of Area Impoundments Environs of the Rocky Flats Plutonium Plant– Colorado," February 1975, by EPA (Appendix E, Document E-3)	Surf Sed: <0.06-4.1	1.4	20
	Sed Core: <0.02-4.5	0.97	15
"Survey of Reservoir Sediments," August 1974, by Dow Chemical (Appendix E, Document E-4)[2]	Surf Sed: 0.68-7.9	3.4	5
	Sed Core: 0.001-5.3	0.42	13
"Radionuclide Concentrations in Reservoirs, Streams and Domestic Waters Near the Rocky Flats Installation," April 1981, by Battelle PNL (Appendix E, Document E-5)[3]	Sed Core: 0.01-8.2	2.7	7
"Great Western Reservoir Spillway Sediment Sampling Program Phase I Report," May 1979, by Rockwell International (Appendix E, Document E-7)[4]	Surf Sed: 0.013-0.083	0.04	14
	Sed Core: 0.007-0.192	0.074	14
"Great Western Reservoir Spillway Sediment Sampling Program Phase II Report," August 1980, by Rockwell International (Appendix E, Document E-8)[4]	Sed Core: 0.006-0.07	0.04	7
	Surf Sed: 0.2-6.1	3.5	48

TABLE 2-3

GREAT WESTERN RESERVOIR PLUTONIUM ANALYTICAL DATA (Concluded)

Data Source	Range (pCi/g or l)	Average (pCi/g or l)	No. of Data Points
"Great Western Reservoir Sediment Cores," February 1985, by Rockwell International (Appendix E, Document E-9)	Sed Core: 0.013-5.4	1.2	4

[1]Surface sediment grab sample–typically represents upper 5 cm of sediments.
[2]Results are for samples collected in 1973 by EPA and split with DOE. Surface sediment grabs analyzed by Rocky Flats laboratory; sediment cores analyzed by Battelle Pacific Northwest Laboratory and Lawrence Livermore National Laboratory.
[3]Collected numerous water and sediment samples in which plutonium concentrations were not measured.
[4]Great Western Reservoir spillway sediments; sampled prior to removal and disposal.

Western Reservoir sediments of selected radionuclides other than plutonium and of beryllium. No significant variations in the concentrations of these potential RFP contaminants were observed throughout the reservoir or between Great Western Reservoir and Standley Lake (IHSS 201) (EPA, 1975).

The 1970 and 1973 EPA studies also sought to confirm the estimated plutonium baseline (background) level by sampling sediments from Front Range reservoirs believed to be unaffected by the RFP. During the 1970 study, sediment samples were collected from Calkins Lake and Autrey Reservoir (EPA, 1971; EPA, 1973). During the 1973 study, samples were collected from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir (EPA, 1975). With one exception, analysis of samples from these reservoirs yielded plutonium-239 levels below $\leq$0.1 pCi/g (0.0037 Bq/g), substantiating EPA's estimated baseline concentration.

An accidental release of tritium from the RFP into Walnut Creek and Great Western Reservoir occurred in 1973 (EPA, 1974). Subsequent studies measured tritium concentrations in reservoir water as a result of the release. Tritium contamination in reservoir sediments has not been studied; however, tritium would not be expected to concentrate in sediments because of its high mobility in the environment (Rockwell, 1988c).

In 1974, Battelle Pacific Northwest Laboratories conducted an investigation of radionuclide concentrations in reservoir and stream sediments near the RFP. Concentrations of plutonium-239, plutonium-240 and americium-241 in the sediments of Great Western Reservoir and Walnut Creek were found to exceed "baseline levels" (presumably the EPA baseline of $\leq$0.1 pCi/g [0.0037 Bq/g]). The study estimated the total inventories of plutonium and americium in Great Western Reservoir sediments at 244 millicurie (mCi) and 73 mCi (9.02 and 2.7 gigabecquerel [GBq]), respectively. Concentrations of cesium-137 were at or below expected baseline concentrations. Age-dated sediment cores (using cesium-137 as an age-dating marker) collected during this study from Great Western Reservoir demonstrated two separate periods of plutonium deposition, 1968 to 1969 and 1959 to 1964, both of which coincide with recorded, controlled waterborne releases from the RFP. Worldwide fallout from atmospheric nuclear weapons testing may also have contributed to the plutonium in the 1968 to 1969 sediment layer (Battelle, 1981). The 1968 to 1969 peak detected in the Battelle study also corresponds to a period of windborne releases from the 903 Pad, a former drum storage area near the eastern end of the RFP controlled area (Figure 2-1) (DOE, 1991a).

Also in 1974, Colorado State University conducted a study of plutonium in aquatic systems of the RFP environs. This study concluded that the clay fraction of RFP sediments has an extremely high affinity for plutonium and, left undisturbed, provides an excellent retention mechanism for plutonium in the aquatic system. Laboratory studies related to this investigation showed that the adsorption of plutonium onto the sediments was rapid and essentially irreversible (CSU, 1974).

Results of studies conducted through 1974 were summarized in a 1975 report by Dow Chemical. According to this report, the studies demonstrated that plutonium in surface water impoundments is not readily transported from the impoundments. Consequently, the majority of the plutonium released through RFP surface waters was contained in the onsite holding ponds. Plutonium concentrations in Walnut Creek sediments increased downstream, suggesting downstream migration of plutonium released at an earlier time (Dow, 1975).

In 1979 and 1980, Rockwell International measured plutonium and americium concentrations in sediments on the Great Western Reservoir overflow spillway prior to removal and disposal of the sediments by the City of Broomfield. Levels of plutonium-239, plutonium-240, and americium-241 in spillway sediment samples were near regional atmospheric fallout background concentrations. Plutonium concentrations averaged 0.04 pCi/g and peaked at 0.19 pCi/g in the spillway sediments. Plutonium and americium concentrations in the spillway sediments varied little with depth, supporting the conclusion that the sediments accumulated through a combination of hillslope erosion, wave action, and sediment mixing, rather than the continuous lacustrine deposition typical of the reservoir bottom sediments (Rockwell, 1979c; Rockwell, 1980).

In 1983, Rockwell International collected 48 sediment surface grab samples and four sediment cores during an extensive Great Western Reservoir geochemical sampling project. Duplicate cores were collected at three locations for joint analysis by the City of Broomfield. The results of this study were not published in report form, but were summarized in public meetings. Maximum recorded plutonium concentrations in these cores were 5.4 pCi/g (Rockwell) and 4.9 pCi/g (Broomfield), occurring at depths of 17 in (43 cm) and 7.5 in (19 cm), respectively. The study indicated that plutonium existed in a discrete sediment horizon corresponding with historical releases from the RFP, and that this horizon had been buried to varying depths by subsequent sedimentation. Sedimentation rates based on core samples were determined to vary from >1.4 in/yr (>3.5 cm/yr) in the eastern, deeper areas of the reservoir to <0.1 in/yr (<0.25 cm/yr) in the shallower areas (Rockwell, 1985c). It was also concluded that no evidence of plutonium migration through the sediment column existed (Rockwell, 1988c).

Numerous studies have focused on surface soil plutonium contamination east of the RFP (DOE, 1991a). Elevated plutonium concentrations have been measured in surface soils north, west, and south of Great Western Reservoir as a result of windborne releases from the 903 Pad, a former drum storage area within the RFP (Figure 2-1). The distribution of surface soil plutonium contamination around the reservoir suggests that windborne particulates have contributed to the plutonium in Great Western Reservoir sediments.

2.2.3.2 Reservoir and Drainage Water Quality

Surface water quality in North and South Walnut Creeks and in Great Western Reservoir has been monitored since shortly after the RFP opened in 1951. Tap water is also monitored for prospective RFP-derived contaminants in a number of municipalities around the RFP, including the City of Broomfield, which is supplied by Great Western Reservoir (see Subsection 1.3.7) In addition, a number of historical studies have focused on potential impacts to IHSS 200 water quality as a result of RFP releases.

A 1973 EPA study concluded that dissolved plutonium concentrations in water samples from Great Western Reservoir and Walnut Creek were less than atmospheric fallout-derived baseline concentrations of <0.03 picocuries per liter (pCi/l) (<0.001 Bq/l). Dissolved uranium concentrations were less than the expected natural background of 2.5 micrograms per liter (EPA, 1975).

An accidental release of tritium in 1973 from the RFP into Walnut Creek and Great Western Reservoir was the focus of another EPA study. The EPA estimated that the release resulted in a total committed dose of 4 millirem (0.04 millisievert) to the average individual using the reservoir as a source of drinking water. The EPA found that this dose had minimal impact on public health and did not recommend any mitigative actions (EPA, 1974). Tritium concentrations in Great Western Reservoir waters returned to approximately background levels by 1977 (Rockwell, 1988c). Tritium is one of the radionuclides routinely monitored in RFP surface water effluents and nearby public water supplies (Dow et al., 1971 to date).

Historical data for Great Western Reservoir indicates the reservoir is generally at its lowest capacity in March, April, and May, and at its highest capacity in July, August, and September. During March, April, and May, the average reservoir storage from 1987 through 1990 was 1,900 acre-feet. During July, August, and September, the average reservoir capacity was 3,100 acre-feet. Additional information regarding historical flows from ditches surrounding Great Western Reservoir has been obtained and will be summarized in the OU 3 RFI/RI Report.

In 1974, Battelle conducted an investigation of radionuclide concentrations in reservoirs, streams, and domestic tap waters near the RFP. Plutonium-239, plutonium-240, and americium-241 concentrations in Great Western Reservoir and Walnut Creek water were slightly above the expected atmospheric fallout background, which was not specifically quantified in this study. Concentrations of these three radionuclides in Broomfield tap water were slightly above the detection limit of 4.5×10^{-4} pCi/l (1.7×10^{-5} Bq/l) but were more than four orders of magnitude lower than the EPA National Primary Drinking Water Regulation of 15 pCi/l (0.55 Bq/l) for total long-lived alpha activity (exclusive of radon and uranium) (Battelle, 1981).

A 1981 Rockwell International study statistically compared available gross alpha and plutonium monitoring data for Great Western Reservoir water and Broomfield tap water with plutonium and gross alpha data for other regional water bodies and supplies. All of the comparisons (with the exception of those for Ralston Reservoir water, in which very low plutonium concentrations were found) indicated that concentrations of plutonium and gross alpha in the regional waters did not statistically differ from those in Great Western Reservoir water and Broomfield tap water (Rockwell, 1981).

Water from Great Western Reservoir is filtered at the Broomfield Water Treatment Plant. The filters are routinely backwashed into a settling lagoon at the plant. Accumulated backwash sludge is periodically removed from the lagoon and analyzed for a variety of parameters, including plutonium, prior to disposal. Plutonium above background concentrations has not been detected in the sludge in past analyses. Filter sludge was last analyzed and removed from the lagoon approximately 5 years ago (Broomfield, 1990). Filter sludge was also analyzed at the Broomfield plant by the EPA (1971) and Battelle (1981b).

2.3 IHSS 201 (STANDLEY LAKE)

The IHSS 201 encompasses Standley Lake, offsite reaches of Woman Creek (which flows into the reservoir from the RFP), and downstream surface water features possibly impacted by outflow from the reservoir (Figure 2-1). Portions of Woman Creek within the boundaries of the RFP will be investigated as RFP OU 5 and are not included in IHSS 201.

2.3.1 Location and Description

Standley Lake is a large reservoir located approximately 2 mi (3.2 km) southeast of the RFP's eastern boundary (Figure 2-1) in Sections 16, 17, 20, 21, 22, and 28, T2S R69W. Uses of the reservoir include municipal water supply and recreation. The reservoir has been owned by The Farmers Reservoir and Irrigation Company of Brighton, Colorado, since its construction between 1909 and 1919. Although the dam has undergone periodic maintenance and reconstruction, most recently in 1978, Standley Lake's present volume of 43,000 acre-feet (5,300 hectare-meters) has remained relatively unchanged since its construction. Approximately 67 percent of the reservoir water is used as municipal water supply for the cities of Westminster, Northglenn, and Thornton. The remaining 33 percent is transported through irrigation ditches to agricultural areas northeast of the lake, primarily between Broomfield and Fort Lupton. Standley Lake receives approximately 96 percent of its water from Clear Creek via an irrigation ditch, but is also fed by Woman Creek (Figures 1-3 and 2-1), which drains the southern side of the RFP (Farmers, 1990).

Historical data for Standley Lake indicates the lake is at its lowest capacity during January, February, and March, and at its highest capacity during June, July, and August. The lowest capacity in Standley Lake has been approximately 29,900 acre-feet, in January of 1989, and its highest capacity was approximately 43,300 acre-feet, in June of 1988 through 1991 (data from 1988 through 1991 was reviewed). Additional information regarding historical flow from ditches surrounding Standley Lake has been obtained and will be summarized in the OU 3 RFI/RI Report.

2.3.2 IHSS Conditions

Although little site-specific information is available concerning the geology and groundwater hydrology of IHSS 201, plantwide hydrogeologic studies give an indication of conditions in the vicinity of the RFP. The following sections summarize relevant results of these studies and provide site-specific information where available.

2.3.2.1 Geology and Groundwater Hydrology

A geologic characterization of Standley Lake was performed by Mineral Systems, Inc. in 1982 to provide data for the enlargement of the dam and reservoir. Bedrock outcrops at various locations around the lake consist of claystone with interbedded sandstone lenses, probably of the Arapahoe Formation. These units dip gently to the northeast. Overlying the bedrock are surficial deposits averaging 15 to 20 ft (5 to 7 m) thick, consisting of a series of alluvial terraces, colluvium, and minor other deposits. No faults have been identified in the area (Hydro-Triad, 1982). Although other site-specific information concerning Standley Lake geology and groundwater hydrology are lacking, it is expected that conditions in the immediate vicinity of the reservoir are similar to those described in Subsection 2.2.2.1 for Great Western Reservoir.

2.3.2.2 Surface Water

Within the RFP boundary, the Woman Creek drainage contains the two C-series holding ponds, Ponds C-1 and C-2 (south and east of the main production area, respectively) (Figures 1-2 and 2-1). Pond C-1 receives flow from Woman Creek. This flow is diverted around Pond C-2 and back into the Woman Creek channel downstream of Pond C-2. Pond C-2 receives surface runoff from the South Interceptor Ditch which collects surface runoff from the southern portion of the RFP main production area (Rockwell, 1988a). The South Interceptor Ditch runs along the south (downgradient) side of the main production area, between the controlled area and Woman Creek (Figure 1-2). Pond C-2 water formerly was discharged into Woman Creek in accordance with the NPDES permit for the RFP. More recently, water was pumped from Pond C-2 into a treatment facility, then through an aboveground pipeline to the Broomfield Diversion Ditch, where it was discharged in accordance with applicable regulations and by agreement with the City of Broomfield. Options to discharge Pond C-2 water to the Broomfield Diversion Ditch or to Ponds A4/B5 are being completed. Treatment of this water will be provided on a contingency basis, as required to meet applicable regulations. Surface water controls within the RFP allow the RFP to effectively prevent runoff from the main production facility (the controlled area shown in Figure 2-1) from reaching Standley Lake.

2.3.2.3 Biota

The aquatic biota in this reservoir are typical for large bodies of water in this area, but an inventory and characterization have not been published. CDH fish toxicity monitoring in Standley Lake has determined that the fish were safe for human consumption. The species analyzed were walleyes, channel catfish, smallmouth bass and rainbow trout. Other species of fish may occur in this reservoir but were not sampled. Bald eagles have been sighted at Standley Lake, especially during the winter and spring, and they prey on fish in the lake.

2.3.3 Nature of Contamination

Radioactive materials released from the RFP may have been transported to Standley Lake through surface water (primarily in suspended sediments) and/or airborne particulates (fugitive dust). Between 1952 and 1973, the RFP discharged water treatment facility filter backwash into Pond C-1, which discharges into Woman Creek (Rockwell, 1988c). At present, only buffer zone surface runoff and natural groundwater seepage flow into the Woman Creek drainage within the RFP boundary (Dow et al., 1971 to date).

Prospective RFP sources of contaminants other than plutonium to Standley Lake, particularly VOCs and uranium, exist in OU 1 (881 Hillside) and OU 2 (903 Pad, Mound, and East Trenches). Herbicides, which have been applied in the past at various locations on the RFP, have also been detected in RFP surface water. The fate and mobility of these potential contaminants are addressed in the conceptual model for reservoirs (Subsection 2.5.2). Available information from onsite and offsite RFP environmental monitoring (Subsection 1.3.8) and RFP OU investigations are used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6.2).

The following sections present chronological summaries of environmental studies conducted to date of IHSS 201. Analytical results from these studies are summarized in Table 2-4. Many of the studies conducted at Great Western Reservoir (Subsection 2.2.3) also included Standley Lake. Reports associated with these studies are incorporated by reference to the list of references in Section 12.0 in this document.

2.3.3.1 Reservoir and Drainage Sediments

The EPA collected four surface grab samples and two cores of bottom sediments from Standley Lake in 1970. The results indicated possible plutonium contamination above the estimated $\leq$0.1 pCi/g (0.0037 Bq/g) baseline concentration (worldwide atmosphere fallout) in the deeper areas of the reservoir. EPA concluded that elevated plutonium in Standley Lake resulted from unspecified

TABLE 2-4

STANDLEY LAKE
PLUTONIUM ANALYTICAL DATA

Data Source	Range (pCi/g or l)	Average (pCi/g or l)	Number of Data Points
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Golden, Colorado, 1970," April 1971, by EPA (Appendix E, Document E-1)	Surf Sed[1]: 0.04-0.05	0.045	2
	Water: <0.02	<0.02	1
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Colorado, 1970, Part II," December 1973, by EPA (Appendix E, Document E-2)	Surf Sed: 0.05-0.21	0.13	2
	Sed Core: 0.09-0.37	0.19	2
	Water: <0.02	<0.02	1
"Plutonium Levels in the Sediment of Area Impoundments Environs of the Rocky Flats Plutonium Plant—Colorado," February 1975, by EPA (Appendix E, Document E-3)	Surf Sed: <0.02-0.17	0.07	17
	Sed Core: <0.03-0.16	0.07	8
"Survey of Reservoir Sediments," August 1974, by Dow Chemical (Appendix E, Document E-4)[2]	Surf Sed: 0.13-3.16	1.3	6
	Sed Core: 0.00007-0.109	0.016	8
"Radionuclide Concentrations in Reservoirs, Streams and Domestic Waters Near the Rocky Flats Installation," April 1981, by Battelle PNL (Appendix E, Document E-5)[3]	Surf Sed: 0.15-0.29	0.22	3
	Water: 0.0015	0.0015	1
"Time Pattern of Offsite Plutonium Contamination from Rocky Flats Plant by Lake Sediment Analyses," July 1978, by DOE (Appendix E, Document E-6)	Sed Core: 0.03-0.56	0.15	2

TABLE 2-4

STANDLEY LAKE
PLUTONIUM ANALYTICAL DATA
(Concluded)

Data Source	Range (pCi/g or l)	Average (pCi/g or l)	Number of Data Points
"Standley Lake Sediment Sample Collection Summary," September 1984, by Rockwell International (Appendix E, Document E-10)	Surf Sed: ND[4]-0.55	0.04	63
	Sed Core: 0.052-0.61	0.12	2

[1]Surface sediment grab sample–typically represents upper 5 cm of sediments.
[2]Results are for samples collected in 1973 by EPA and split with DOE. Surface sediment grabs analyzed by Rocky Flats laboratory; sediment cores analyzed by Battelle Pacific Northwest Laboratory and Lawrence Livermore National Laboratory. Reported values from Rocky Flats laboratory are much higher than those recorded in other Standley Lake sampling programs. Very low confidence in these values.
[3]Collected numerous water and sediment samples in which plutonium concentrations were not measured.
[4]ND = below 1984 Rocky Flats laboratory detection limit of 0.002 pCi/g.

releases from the RFP and speculated that these releases occurred from surface water erosion and transport of plutonium-contaminated soil (EPA, 1971; EPA, 1973).

EPA resumed their investigation of plutonium in surface water sediments east of the RFP in 1973. Analysis of 17 surface grab samples and eight cores of Standley Lake sediments yielded plutonium concentrations above estimated baseline concentrations in only two of the surface grab samples. Plutonium concentrations in the cores taken at the locations of these grab samples were similar to baseline concentrations ($\leq$ 0.1 pCi/g). EPA believed the cores to be more representative of actual conditions at the two locations, and concluded that the collective sampling effort did not indicate any discernable plutonium contamination in Standley Lake sediments attributable to RFP releases (EPA, 1975).

During a 1974 investigation of radionuclides in the sediments of reservoirs and streams near the RFP, Battelle Pacific Northwest Laboratories collected eight surface sediment grab samples and a single sediment core from Standley Lake. Several samples contained plutonium above EPA estimated baseline levels of $\leq$0.1 pCi/g (0.0037 Bq/g). Based upon the single core sample, Battelle extrapolated total plutonium and americium inventories for Standley Lake sediments at 60 and 18 mCi (2.2 and 0.7 GBq/g), respectively. The core also suggested that cesium-137 levels in Standley Lake sediments were typical of atmospheric fallout baseline levels. The Battelle study did not attempt to define the historical source of Standley Lake plutonium contamination (Battelle, 1981).

Separate studies of plutonium in the surface water systems in the vicinity of the RFP concluded that: (1) plutonium rapidly and almost irreversibly attaches itself to clay sediments (CSU, 1974), and; (2) plutonium in surface water impoundments does not move very far or very rapidly through subsurface waters, meaning that the majority of the plutonium released through RFP surface waters was contained in the onsite holding ponds (Dow, 1975).

The DOE collected two sediment cores from Standley Lake in August 1976, and determined through correlation of peak radionuclide concentrations in the longer core that it represented approximately 14 years of sedimentation (1962 to 1976). This dating enabled DOE to calculate an average sedimentation rate for the core location of 1.3 in/yr (3.4 cm/yr), and to conclude that plutonium concentrations in the core location exceeded baseline levels since 1966, peaked in 1969, and declined after 1969. The report attributed 70 percent of the plutonium in Standley Lake to releases from the RFP and speculated that this plutonium was transported both by airborne particulates and by soil erosion within the lake drainage basin (such as surface water). The time correlation of plutonium deposition in the core corresponded with the known period of windborne plutonium release from the 903 Pad at the RFP (Figure 2-1) (DOE, 1978).

Rockwell International conducted an extensive sediment sampling program at Standley Lake in 1984 to evaluate sediment plutonium concentrations and to compare the results with previous work. A total of 63 surface sediment grab samples and four sediment cores were collected by Rockwell, of which seven grab samples and two cores were collected jointly with the City of Westminster. The results of this study were not published in report form, but were summarized in public meetings. A maximum concentration of 0.61 pCi/g (0.02 Bq/g) was detected at a depth of 6.3 to 7.1 in (16 to 18 cm) in one core. The maximum plutonium concentration measured in the surface sediment grab samples, which potentially represented a sediment depth of several inches, was 0.55 pCi/g (0.018 Bq/g) (Rockwell, 1984).

In 1989, the CDH analyzed various species of fish collected from Standley Lake to determine if they were safe for human consumption. The fish were analyzed for selected metals, radionuclides (including plutonium-239, plutonium-240, and cesium-137), and priority organic pollutants. No radionuclides were detected in the fish; however, low concentrations of cadmium, mercury, selenium, and the pesticides DDT, DDE, DDD, and malathion were detected. The report stated that the source(s) of these contaminants was indeterminate, but that none of the contaminants detected were unique to the RFP. It was concluded that the contaminants may have originated from a variety of sources in the watershed, including water diverted from Clear Creek, which contributes 96 percent of the influent to Standley Lake (CDH, 1990c).

2.3.3.2 Reservoir and Drainage Water Quality

Surface water quality in Woman Creek and Standley Lake has been monitored since shortly after the RFP opened in 1951. Tap water is also monitored for prospective RFP-derived contaminants in a number of municipalities around the RFP, including the cities of Westminster, Thornton, and Northglenn, which are supplied by Standley Lake (see Subsection 1.3.7). In addition, several historical studies have focused on potential impacts to Standley Lake water quality as a result of RFP releases.

A 1973 study by the EPA concluded that dissolved plutonium concentrations in water samples from Standley Lake were less than atmospheric fallout-derived baseline concentrations of <0.03 pCi/l (0.001 Bq/l). Dissolved uranium concentrations were less than the expected natural background of 2.5 micrograms per liter (EPA, 1975).

Battelle Pacific Northwest Laboratories analyzed Standley Lake water as part of their investigation of radionuclide concentrations in reservoirs, streams and domestic waters near the RFP. Plutonium-239, plutonium-240, and americium-241 concentrations in Standley Lake water were above the expected atmospheric fallout background, which was not specifically quantified in this study, but were more than four orders of magnitude lower than the EPA National Primary Drinking Water Regulation of 15 pCi/l (0.55 Bq/l) for total long-lived alpha activity (exclusive of radon and uranium). Concentrations of these three radionuclides were below detection limits of 4.5×10^{-4} pCi/l (1.7×10^{-5} Bq/l) in Westminster tap water (Battelle, 1981).

Filtration of Standley Lake influent occurs at the Northglenn, Thornton, and Westminster water treatment plants. Discussions with personnel at each of these facilities indicate that filter backwash sludge is not and has not previously been analyzed for plutonium or gross alpha activity.

2.4 IHSS 202 (MOWER RESERVOIR)

IHSS 202 encompasses Mower Reservoir, offsite reaches of the irrigation ditch which feeds the reservoir from Woman Creek, and downstream surface water features possibly impacted by outflow from the reservoir (Figure 2-1). Portions of this irrigation ditch within the boundaries of the RFP are part of RFP OU 6 and are not included in IHSS 202.

2.4.1 Location and Description

Very little documentation exists for Mower Reservoir, a small, privately-owned impoundment located just southeast of the RFP in Section 18, T2S R69W. The reservoir is fed by Woman Creek via Mower Ditch an irrigation ditch that originates within the RFP boundary (Figure 1-3). Mower Reservoir is used for agricultural purposes, primarily cattle watering and irrigation, and fluctuates in capacity depending upon water supply and demand. It covers an area of approximately 9 ac (3.6 ha) and is roughly 50 ft (15 m) deep at its deepest point (Personal communication, 1990). Outflow from Mower Reservoir flows southeast from the reservoir, eventually discharging to Standley Lake (Figure 1-3). Mower Reservoir is located on land, that was the subject of a lawsuit against the RFP by several landowners, alleging contamination of the land surface by releases from the plant (DOE, 1991a).

2.4.2 IHSS Conditions

No site-specific information is available for geologic and groundwater conditions at Mower Reservoir. The geology and groundwater hydrology of Mower Reservoir are expected to be similar to those described for Great Western Reservoir (Subsection 2.2.2.1). Because Mower Reservoir is fed by a diversion from Woman Creek, surface water pathways from the RFP to Mower Reservoir are similar to those described for Standley Lake (Subsection 2.3.2.2). Biota at Mower Reservoir are expected to be similar to those at Great Western Reservoir (Subsection 2.2.2.3) and Standley Lake (Subsection 2.3.2.3).

The DOE recently examined the possibility of discharging water from RFP holding Pond C-2 to Mower Reservoir via Woman Creek and Mower Ditch (Figure 2-3). The following conditions would have to be met in order to discharge Pond C-2 water to Mower Reservoir:

- All site-specific CWQCC discharge standards would have to be met by the RFP (see Section 2.2.2.2 of this document)
- Permission would have to be obtained from the owner of Mower Reservoir
- Assurance would have to be obtained from the reservoir owner that the water would be used only for agricultural purposes

2.4.3 Nature of Contamination

In contrast to the extensive historical sampling data available for Great Western Reservoir and Standley Lake, only very limited data have been collected to characterize Mower Reservoir. Because the reservoir is not a public water supply, its water quality is not monitored and has not previously been evaluated. RFP-derived contaminants in Mower Reservoir are believed to have been transported primarily as airborne particulates, and to a lesser degree by surface water through the Woman Creek drainage, which may have contributed to plutonium concentrations in Standley Lake sediments (see Subsection 2.3.3). It can be inferred that contaminant concentrations resulting from releases into Woman Creek would be similar for Mower Reservoir and Standley Lake, while concentrations resulting from airborne releases, and from erosion and transport of contaminated soils by surface runoff, would be similar for Mower Reservoir and Great Western Reservoir.

Mower Reservoir sediments were sampled in 1970 during EPA's initial study of radioactive contamination in the aquatic environs of the RFP. A total of four surface sediment grab samples were collected. Plutonium concentrations in these samples ranged from 0.09 to 0.18 pCi/g and averaged 0.14 pCi/g, slightly exceeding EPA's estimated baseline concentration of $\leq$0.1 pCi/g (EPA, 1971;

DRAWN BY	Douville 11/18/91	CHECKED BY	PBS 11-23-91	DRAWING NUMBER	RF1032
		APPROVED BY	ALL 11-25-91		

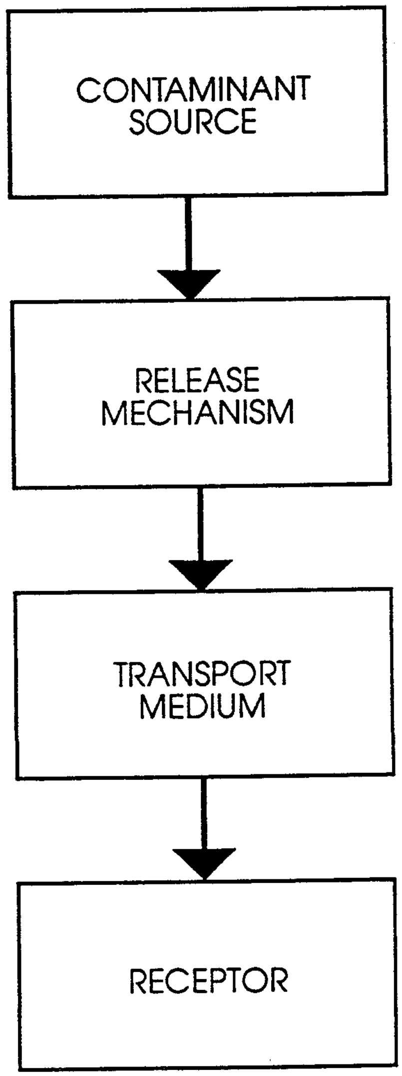


Figure 2-12
Components of a Completed Exposure Pathway

EPA, 1973). No further characterization of Mower Reservoir contamination has been conducted since this 1970 sampling effort.

Numerous investigations have focused on elevated plutonium concentrations in surface soils around Mower Reservoir (DOE, 1991a). These studies have concluded that the primary source of the plutonium was windborne particulates from the 903 Pad (Figure 2-1). It is expected that Mower Reservoir received similar amounts of plutonium through airborne transport as the nearby land surface.

2.5 CONCEPTUAL MODELS

Utilizing the information obtained in past studies of OU 3, conceptual models of contaminant exposure pathways for offsite soils (IHSS 199) and reservoirs (IHSS 200, 201 and 202) are presented here for use in the evaluation of the potential risks of OU 3 contamination to human health and the environment.

The primary purpose of the conceptual models is to aid in identifying exposure pathways by which populations may be exposed to contaminants from the IHSSs. The EPA defines an exposure pathway as "...a unique mechanism by which a population may be exposed to the chemicals at or originating from the site..." (EPA, 1989c). As shown in Figure 2-12, an exposure pathway must include a contaminant source, a release mechanism, a transport medium, an exposure route, and a receptor. An exposure pathway is not complete without each of these five components. The individual components of the exposure pathway are defined as follows:

- **Contaminant Source:** For purposes of the OU 3 conceptual models, the contaminant sources are the media in each IHSS which are known to have been or which potentially have been directly affected by releases from the RFP. These source media are the surface soils at IHSS 199 and the sediment and surface water of IHSS 200, 201, and 202. Because known contaminants at OU 3 have been traced to past releases from the RFP, the plant is shown in the models as a historical contaminant source to the IHSSs.

- **Release Mechanism:** Release mechanisms are physical and/or chemical processes by which contaminants are released from the source. The conceptual models identify mechanisms which release contaminants directly from the source and those which release contaminants from transport media (i.e., secondary release mechanisms). Numerous potential release mechanisms and secondary release mechanisms for OU 3 are discussed in the conceptual models.

- **Transport Medium:** Transport media are the environmental media into which contaminants are released from the source and from which the contaminants are in turn released to a receptor (or to another transport medium by a secondary release mechanism). Potential transport media for OU 3 include air, surface water, groundwater, and biota (both flora and fauna).

- **Exposure Route:** Exposure routes are avenues through which contaminants are physiologically incorporated by a receptor. Exposure routes for receptors at OU 3 are inhalation, ingestion, and dermal contact.

- **Receptor:** Receptors are human or environmental populations that are affected by the contamination released from a site. Human receptors for OU 3 include nearby residents and visitors to the area. Environmental receptors include biota (both flora and fauna) indigenous to the OU 3 environs.

The conceptual models provide a contaminant source characterization and an overview of all the potential exposure pathways that may result from releases from and/or into each transport medium. Some of these pathways have a higher potential for occurrence than others. Significant exposure pathways have been identified by evaluating the fate and mobility of the contaminant in each potential source and transport medium that are included in the conceptual models.

2.5.1 Conceptual Model for Offsite Surface Soils (IHSS 199)

The general conceptual model for offsite surface soils is shown in Figure 2-13. The exposure pathways for the various elements of the conceptual model are explained in the following subsections. The IHSS 199 pathways are prioritized based on the Past Remedy Report (DOE, 1991a) and are presented in Figure 2-14. The primary exposure pathway, from a human health risk standpoint, is inhalation of soil dispersed to air through wind erosion. The secondary pathway is direct ingestion of soil. The remaining pathways are believed to constitute a negligible risk to human health but are addressed in the work plan. The pathways were used to design the field sampling plan for OU 3 (see Section 6.0). Each numbered pathway is presented in detail in Appendix A. The pathways are referenced throughout the work plan to show how each pathway is being addressed.

2.5.1.1 Historical Contamination Source

As shown in Figure 2-13, the RFP is considered the historical contamination source to the offsite surface soils. Based on information presented in Sections 1.0 and 2.0 on RFP geographical setting and environmental monitoring, the airborne pathway is considered the only reasonable migration pathway that could transport contamination from the RFP to offsite surface soils. Known and potential RFP impacts on IHSS 199 are discussed in Subsection 2.1.4.1. An understanding of the fate and mobility of the potential contaminants involved is useful in determining whether they could reasonably have impacted offsite surface soils and, if so, whether they still exist in the soils today.

Chemical and physical characteristics of chemicals and environmental media affect the environmental fate and transport of a chemical. Table 2-5 presents some of the relevant chemical/ physical parameters that control the environmental fate and transport of representative organic chemicals.

Target Compound List (TCL) volatiles generally are more mobile in the environment than other chemicals. Volatiles are generally characterized by relatively high water solubility (greater than

TABLE 2-5

CHEMICAL/PHYSICAL PARAMETERS AFFECTING
ENVIRONMENTAL FATE AND TRANSPORT
FOR ORGANICS

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry's Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env. Mobility
TCL VOLATILE ORGANICS										
Ketones & Aldehydes										
Acetone	55.1	0.1	270.00	0.013	60000.0	-0.24	-0.43	1.0	8	Extremely Mobile
Monocyclic Aromatics										
Benzene	78.1	0.9	76.00	0.182	1780.0	2.13	1.81	6.8	3	Very Mobile
Toluene	92.1	0.9	22.00	0.214	515.0	2.79	2.48	28.0	2	Very Mobile
Ethyl Benzene	106.2	0.9	7	0.266	152.0	3.34	3.04	100.0	-0	Slightly Mobile
Xylene	106.2	0.9	10	0.380	152.0	3.13	2.11	12.6	1	Very Mobile
Chlorinated Aliphatics										
Carbon Tetrachloride	153.8	1.6	90.00	0.960	785.0	2.96	2.64	40.5	2	Very Mobile
Trichloroethene	131.4	1.5	60.00	0.390	1100.0	2.42	2.10	12.3	3	Very Mobile
Chloroform	119.4	1.5	160.00	0.130	8000.0	1.97	1.64	4.9	4	Very Mobile
1,1,1,2-Trichloroethane	167.9	1.6	5.00	0.016	2900.0	2.39	2.07	11.6	2	Very Mobile
SEMIVOLATILE ORGANICS										
Acid Extractables (Phenolics)										
Phenol	94.1	1.1	0.20	1.2E-04	8200.0	1.46	1.15	2.3	2	Very Mobile

TABLE 2-5

CHEMICAL/PHYSICAL PARAMETERS AFFECTING ENVIRONMENTAL FATE AND TRANSPORT FOR ORGANICS (Continued)

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry's Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env. Mobility
Pentachlorophenol	266.4	2.0	1.1E-04	1.1E-04	14.0	5.18	4.72	4771.3	-8	Immobile
2,4-Dinitrophenol	184.1	1.7	1.5E-05	2.7E-08	5600.0	1.54	1.22	2.5	-2	Slightly Immobile
2,4,6-Trichlorophenol	197.5	1.5	0.012	1.6E-04	800.0	3.61	3.30	181.0	-2	Slightly Immobile
Base-Neutral Extractables										
Bis(2-ethylhexyl)phthalate	391.1	1.0	2.7E-07	4.4E-06	1.3	9.61	9.30	1.8E+08	-16	Very Immobile
Chrysene	228.2	1.3	1.0E-11	6.9E-08	0.0	5.61	5.30	1.8E+04	-19	Very Immobile
1,2,4-Trichlorobenzene	181.5	1.5	0.29	9.6E-02	30	4.28	3.96	8.3E+02	-3	Slightly Immobile
1,3-Dichlorobenzene	147.0	1.3	2.28	1.5E-01	123	4.28	3.96	8.3E+02	-2	Slightly Immobile
Naphthalene	128.2	1.0	0.087	1.9E-02	31.7	3.29	2.97	8.6E+01	-3	Slightly Immobile
Benzo(a)pyrene	252.0	1.4	5.6E-09	2.0E-05	3.8E-03	6.06	6.74	5.0E+05	-17	Very Immobile

TABLE 2-5

CHEMICAL/PHYSICAL PARAMETERS AFFECTING
ENVIRONMENTAL FATE AND TRANSPORT
FOR INORGANICS
(Concluded)

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry's Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env. Mobility
PCBs AND PESTICIDES										
PCBs										
PCB-1248	299.5	1.4	4.9E-04	1.5E-01	0.054	5.76	5.44	24931.0	-10	Immobile
PCB-1254	328.4	1.5	7.7E-05	4.6E-02	0.0	6.03	5.72	47233.7	-11	Very Immobile
PCB-1260	375.7	1.6	4.1E-05	2.8E-01	0.0	7.15	6.82	594625.1	-14	Very Immobile
Chlorinated Pesticides										
Dieldrin	381.0	1.8	1.8E-07	1.9E-05	0.2	3.54	3.23	153.8	-11	Very Immobile
DDT	375.7	1.6	1.9E-07	7.1E-04	5.5E-03	6.91	6.59	350141.6	-16	Very Immobile
Heptachlor	375.0	1.6	3.0E-04	3.4E-02	0.18	4.4	4.1	1081.0	-8	Immobile
Lindane	291.0	1.6	2.5E-05	2.5E-04	1.6	3.9	3.6	343.0	-8	Immobile
Chlordane	409.8	1.6	1.0E-05	4.0E-03	0.056	5.5	5.1	12601.0	-11	Very Immobile
Toxaphene	414.0	1.6	0.3	1.4E+01	0.5	3.3	3.0	87.8	-4	

Source: EG&G, 1990e

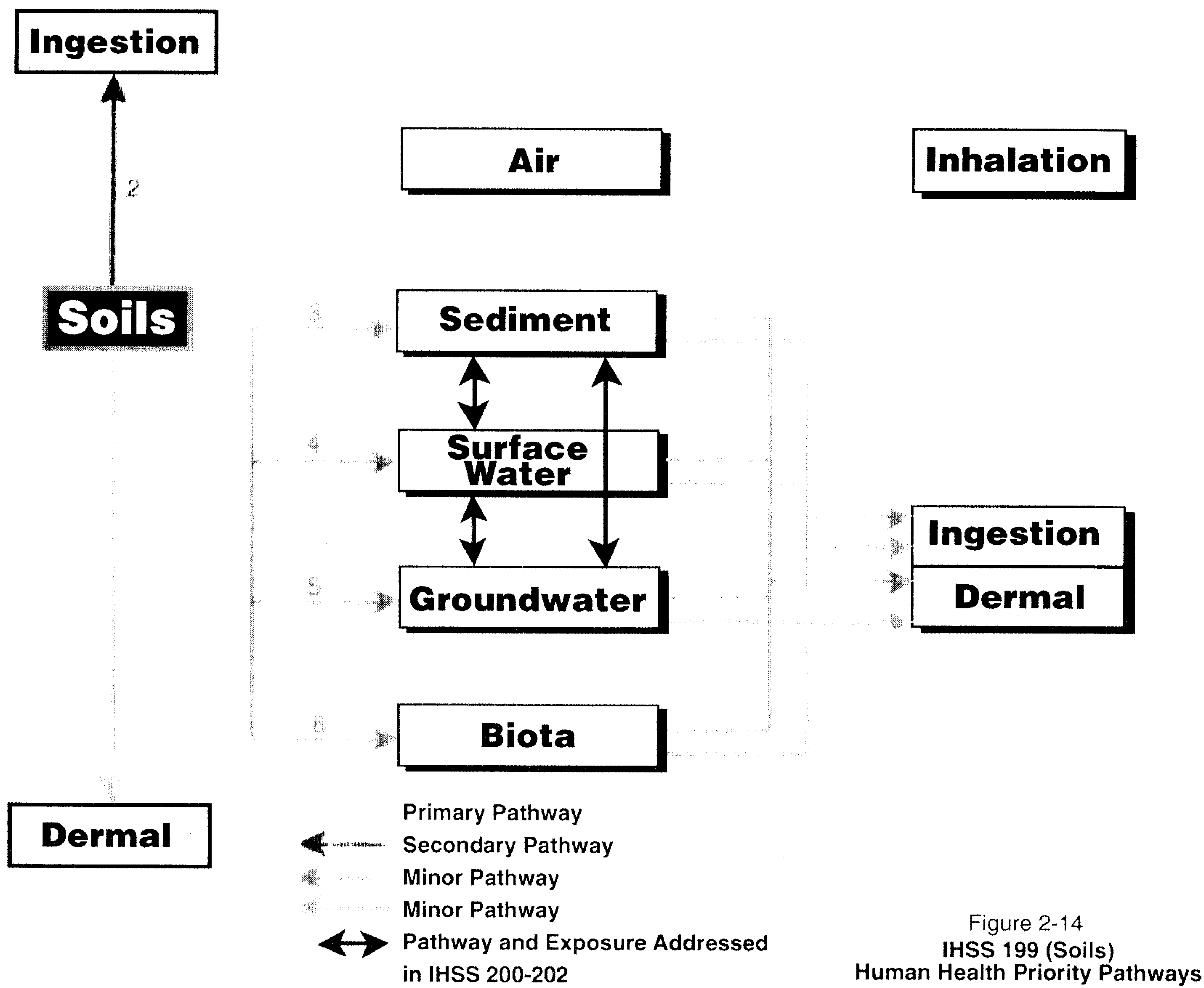


Figure 2-14
IHSS 199 (Soils)
Human Health Priority Pathways

DRAWN BY	H. DOUVILLE	CHECKED BY	A. LANGE	10/25/91	DRAWING NUMBER	RF1020
	10/30/91	APPROVED BY	AL	11/25/91		

100 mg/l) and volatility (vapor pressures greater than 1.0 mm Hg and Henry's Law Constants greater than 0.1). Volatiles can be expected to migrate through soils in both liquid and vapor phase, and to be transported by groundwater and surface water as neutral solutes. This is denoted by retardation factors (Rd) between 1 and 50 (Chemical migration velocity = water migration velocity/Rd). The Henry's Constants of volatiles suggest a tendency to volatilize from aqueous systems (including soil/water) to the atmosphere and, therefore, are unlikely to be detected in soils. Since the airborne pathway is the only reasonable migration pathway contributing to offsite surface soil contamination, it is unlikely that volatile contamination exists in OU 3 soils because of the high likelihood of volatization.

Semivolatile compounds and pesticides/PCBs typically are much less mobile than volatile compounds. The retardation factors for semivolatiles and pesticides/PCBs range from approximately 100 to over 180,000,000 with the exception of phenolic compounds. Phenols are relatively mobile because of their high water solubility. Semivolatiles and pesticides/PCBs exhibit low to negligible volatility as indicated by the low vapor pressures and Henry's Constants. This suggests a low propensity for volatilization of these compounds to the atmosphere from soil and surface water.

Table 2-6 summarizes the distribution coefficients for radionuclides and inorganic elements. The distribution coefficients are considered empirical and are strangely influenced by the environmental conditions existing where the experiments are performed. Inorganic compounds differ from organic compounds in that they can be present in solution in a number of different forms or species. The form of an inorganic chemical is important in evaluating that chemical's mobility. Each species or complex may have different solubilities and the concentration of each can be related to several factors including pH and oxidation/reduction potential.

The following subsection presents specific fate and transport discussions for radionuclides and nonradioactive contaminants that are likely to occur in IHSS 199. The discussion focuses primarily on plutonium since plutonium has been documented as a primary contaminant of concern at IHSS 199.

TABLE 2-6

LITERATURE DISTRIBUTION COEFFICIENTS FOR RADIONUCLIDE AND METALS ELEMENTS

Chemical	Representative Value[1]	Summary Range Low	Summary Range Maximum
Radionuclide			
Americium-241	700	0[4]	47,230[1]
Bismuth-214	200		
Cadmium-109	6.5	1.26[1]	50[3]
Cesium-143	850	3.0[4]	300,000[2]
Cesium-137	1,000	1.3[4]	52,000[1]
Cobalt-60	45	0.2[1]	23,624[4]
Lead-212-Bismuth	900	4.5[1]	7,640[1]
Plutonium-238, 239, 240	4,500	0.4[4]	8.7E7[4]
Potassium-40	5.5	2.0[1]	9.0[1]
Radium-288	450	200[1]	467[4]

[1]U.S. Department of Energy, 1984, A review and Analysis of Parameters for Assessing Transport of Environmental Released Radionuclides through Agriculture.
[2]U.S. Department of Energy, 1980, Determination of Distribution Coefficients for Plutonium, range of results for a variety of sediments in the Enewetak Lagoon using Lab and Field experiments; Transuranic Elements in the Environment, Technical Information Center.
[3]Couphtrey, P. J. and Thorne, M. C., 1983, Radionuclide Distribution and Transport in Terrestrial and Aquatic ecosystems, A Compendium of Data.
[4]ACS Symposium Series, 1979, Radioactive Waste in Geologic Storage (Abyssal Red Clay) Conc=1E3–1E8 mg/atom/ml in 0.68N NaCl Soin Distributed Coefficient for CS pH2.7-8.0 Figure 1; for Cd pH 5.3 Figure 3; for Sr Phy.I-73; for Ba pH 2.6-8.3 Figure 2; for Ce pH 5.8-8.0 Figure 4.

TABLE 2-6

LITERATURE DISTRIBUTION COEFFICIENTS FOR RADIONUCLIDE AND METALS ELEMENTS (Continued)

Strontium-90	35	0.15[1]	4,300[4]
Thorium-228	1,500	5[4]	1E6[4]
Uranium-234	1,500	0[1]	4,400[1]
Metals			
Aluminum	1,500	0[4]	122.8[4]
Antimony	45	1.0[5]	18[5]
Arsenic	200	5[4]	30,000[4]
Barium	60		
Beryllium	650		
Boron	3	1.26[1]	50[4]
Cadmium	6.5		
Chromium	850	0.2[1]	3,800[1]
Cobalt	45	1.4[1]	333[1]
Copper	35	4.5[1]	7,640[1]
Lead	900	0.2[1]	10,000[1]
Manganese	65	30[7]	82,800[7]

[1]U.S. Department of Energy, 1984, A review and Analysis of Parameters for Assessing Transport of Environmental Released Radionuclides through Agriculture.
[4]Radionuclide Interactions with Soil and Rock Media Volume 1: Processes Influencing Radionuclide Mobility and Retention, Element Chemistry and Geochemistry, Conclusions and Evaluation, Battelle Pacific Northwest Labs, Richland, WA EPA No. 6078-007, August 1978.
[5]Dragun, 1988, The Soil Chemistry of Hazardous Materials, Dragun, 1988, Ranges of Kd for various Elements in Soils and Clays, Table 4.2, pg 158.

TABLE 2-6

LITERATURE DISTRIBUTION COEFFICIENTS FOR RADIONUCLIDE AND METALS ELEMENTS (Concluded)

Mercury	10	0.37[1]	400[1]
Molybdenum	20	200[7]	300,000[7]
Nickel	150		
Selenium	300		
Silicon	30	10[1]	1,000[1]
Silver	45		
Thallium	1,500		
Titanium	1,000		
Vanadium	1,000		
Zinc	40	0.1[1]	8,000[1]

[1]U.S. Department of Energy, 1984, A review and Analysis of Parameters for Assessing Transport of Environmental Released Radionuclides through Agriculture.

[7]EPRI, 1984, Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration Volume I. A Critical Review. Battelle Pacific Northwest Laboratories, Richland, WA. EPRI EA-3356, Kd for Ba in River Sediments; Kd for Me= pH=6.6 with Bentonite, Kd-82800 Ph-5.95 for Iron Oxide; Kd=200 for Ni in seawater with Clay pH=8; with Mn Oxide Kd=300,000 pH=8.

2.5.1.1.1 **Radionuclides.** Most of the studies performed to date at IHSS 199 have focused on plutonium contamination. It has been conclusively demonstrated that plutonium has been transported from the RFP via the airborne pathway and affected offsite surface soils immediately east of the RFP. Americium has also been detected in these soils, indicating either direct airborne transport from the RFP or in situ ingrowth with the plutonium in the soils. It is likewise conceivable that airborne transport of uranium to offsite soils could occur. However, it is highly unlikely that tritium would have been transferred via air to IHSS 199.

2.5.1.1.2 **Nonradioactive Contaminants.** Nonradioactive contaminants discussed in Subsection 2.1.4.1 include metals, VOCs, semivolatile organics, and inorganic ions. Nonradioactive metals, particularly beryllium, could feasibly have been transported by air to offsite surface soils. Few potential airborne pathway sources appear to exist on the RFP for metals other than beryllium. It is not likely that VOCs or semivolatile organics have affected offsite surface soils, because these compounds tend to volatilize in air rather than settle out in a discrete surface deposit. It is remotely possible that fugitive dust from the RFP could contain organic compounds that might remain bound to the particles through airborne transport and settle out on surface soils. It is also very unlikely that inorganic ions could be transported via fugitive dust to offsite soils because of their high solubility and tendency to quickly leach into deeper soils.

2.5.1.2 Current Contaminant Source

Contaminated offsite surface soils are considered the current contaminant source at IHSS 199 (Figure 2-13). The following subsections focus on contaminant and soil characteristics that may affect contaminant transport from the surface soils.

2.5.1.2.1 **Contaminant Characteristics.** Surface soils immediately east of the RFP have been shown to contain plutonium and its decay product, americium, in excess of expected background concentrations (as measured at Colorado Front Range sites remote from the RFP). Beryllium and selected radionuclides other than plutonium and americium have also been characterized in these soils, although to a much lesser extent than plutonium. Other potential RFP-derived contaminants, including VOCs and semivolatiles, metals other than beryllium, and inorganic ions, have not been characterized in offsite surface soils. However, the fate and transport characteristics of these contaminants exclude them for OU 3 soils.

Radionuclides

Plutonium and americium are the only RFP-derived radioactive contaminants known to exist in offsite surface soils. Plutonium concentrations in selected offsite surface soils have been well-characterized through numerous sampling programs. Americium is expected as a radioactive decay daughter product of plutonium and apparently has been measured above background concentrations in offsite surface soils (Rockwell, 1985a). Uranium may be associated with the RFP, but is also naturally occurring in bedrock materials in the area. The following discussions focus on characteristics of plutonium and uranium which may affect their fate and mobility from soil into the environment. Numerous studies of plutonium fate and mobility are incorporated by reference into the discussions. Much less information is available on the nature of americium in the environment. Americium has essentially the same characteristics in the environment as plutonium and is considered insoluble under typical environmental conditions.

Plutonium

There are 15 known isotopes of plutonium that decay into other elements at half-lives ranging from hours to 387,000 years (Ames and Rai, 1978). At the RFP, plutonium exists primarily as plutonium-239 and -240 (Table 2-7).

Plutonium speciation in the environment is heavily influenced by hydrogen ion concentration (pH) and oxidation-reduction capacity (Eh). Typical environmental conditions are pH in the range of 5 to 8 and a positive Eh (greater than 0.05 volts) (Brownlow, 1979). Under these conditions, plutonium species will most likely be found in the following order of occurrence: $Pu^{+4} > PuO_2^{+2} > Pu^{+3} > PuO^{+1}$ (Ames and Rai, 1978).

TABLE 2-7

ISOTOPIC COMPOSITION OF ROCKY FLATS PLUTONIUM

Isotopic	Relative Weight (percent)	Specific Alpha Activity (Curies/gram)	Specific Beta Activity (Curies/gram)	Relative[a] Activity (Curies/gram)
Pu-238	0.01	17.1	--	0.00171
Pu-239	93.79	0.0622	--	0.056834
Pu-240	5.80	0.228	--	0.01322
Pu-241	0.36	—	103.5	0.37260
Pu-242	0.03	0.00393	--	1.18×10^{-6}
Am-241	--[b]	3.42	--	--

Source: Rockwell, 1985b.

[a]Relative activity is obtained by multiplying the percent by weight by the specific activity.

Total activity for the plutonium isotopes is:

Alpha 0.0732 curies/gram
Alpha plus Beta 0.446 curies/gram

[b]Am-241 daughter from decay of Pu-241.

As shown above, the most probable species in the environment is the plus 4 valence (oxidation state) species, which will exist either as plutonium dioxide (PuO_2) or as a solid hydroxide, $Pu(OH)_4$ (Brookins, 1984; Dragun, 1988). The assertion is based on the assumption that the pH of the environmental system is not low and that the system is in an oxidative state (Eh > 0.0).
Plutonium shows a very strong tendency to adsorb to clays, metal dioxides, and organic matter in soils and thus has a very low migration potential in the environment (CSU, 1974; Brookins, 1984). The distribution coefficient (K_d), which is the ratio of the concentration of adsorbed material to concentration of material in water at equilibrium, for plutonium is 10^3-10^5 (Allard and Rydberg, 1983), meaning that the ratio of plutonium bound to soil to plutonium dissolved in water would be expected to vary from 1,000:1 to 100,000;1. The EPA (1990b) gives a K_d of $2x10^3$ for plutonium.

Uranium

Uranium has 14 isotopes that decay to other elements at half-lives of minutes to 4.5 billion years. The most important uranium isotopes at the RFP are uranium-234 and -235. Uranium-234 is a daughter product of uranium-238. Uranium-235 is an important enriched uranium isotope for nuclear purposes. U-234 has a half-life of 244 thousand years and U-235, 704 million years.

Uranium occurs in two oxidation states, +4 (typically in solids) and +6 (typically as the dissolved uranyl ion, UO_2^{+2}). Unlike plutonium and americium, uranium is both naturally-occurring and mobile in an oxidizing (e.g., near surface) environment. Uranium has a lower K_d than plutonium or americium. However, under reducing conditions (such as highly-organic, fine-grained, bed sediments deposited in the deeper parts of a reservoir) uranium is immobilized and becomes part of the sediments.

Yang and Edwards (1984) documented the fate and transport of uranium and its daughter product, radium-226, in dissolved form, and in both suspended and bed sediments, from above the Schwartzwalder (uranium) Mine adjacent to Ralston Creek several miles southwest of the RFP. Uranium is present in dissolved and solid phases. Concentrations range from 4 micrograms per liter (µg/l) dissolved in the creek water above the mine to 100 µg/l in Ralston reservoir below the mine.

Uranium occurred as both a discrete mineral and partially entrapped in colloidal iron and manganese coatings on suspended and bed sediments.

Nonradioactive Contaminants

Based on the discussion presented in Section 2.5.1.1, the only nonradioactive contaminants that could reasonably be expected to exist in offsite surface soils are metallic ions. Beryllium is the only nonradioactive metal for which a potential RFP source to the airborne pathway is recognized. It should be noted here that beryllium concentrations were measured in offsite soils in 1971 by CDH. Higher concentrations were found west of the RFP, where deposition resulting from releases to air are very unlikely (CDH, 1991). More probably, the higher concentrations result from increased natural background in the soil derived from granitic rocks, which contain naturally-occurring beryllium oxide. CDH measured beryllium in offsite surface soils around the RFP again in 1989; results were reported as <2.7 ppm for all samples analyzed, consistent with background samples collected at locations remote from the RFP (CDH, 1991).

2.5.1.2.2 Soil Characteristics. A detailed discussion of surface soils in the RFP vicinity is presented in Subsection 2.1.3.1. The organic matter content of the surface soils varies between 2 to 4 percent and the pH values range from 6.6 to 8.4 (near neutral to slightly alkaline). The vertical permeability of these soils is 0.06 to 0.6 in/hr (0.15 to 1.5 cm/hr). Runoff is generally rapid and the water erosion potential is high where soils are not protected by vegetation. The predominant minerals of the fine soil fraction are montmorillonititic clays with calcareous materials (SCS, 1980). As discussed in Subsection 2.1.3.1, surface soil characteristics may have changed on the IHSS 199 remedy acreage as a result of court-ordered tilling.

2.5.1.3 Release Mechanisms and Transport Media

Factors that ultimately determine the processes that may be responsible for releasing contaminants between transport media or to receptors include the contaminant and soil characteristics discussed in the preceding subsection, the climatological characteristics of the site, and the behavior of the contaminant in the various potential transport media.

Preceding discussions have indicated that plutonium and americium are the contaminants likely to exist in offsite surface soils as a result of RFP releases. Plutonium release mechanisms and behavior in transport media have been well-studied at the RFP and elsewhere, while specific information on the environmental fate and transport of americium is sparse. As mentioned in Subsection 2.5.1.2.1, americium is considered to be slightly more mobile than plutonium; however, for practical purposes, the two radionuclides behave similarly in the environment. For these reasons, the following discussions focus on plutonium.

2.5.1.3.1 Climatological Characteristics. Of particular importance to the fate and mobility of contaminants in offsite surface soils are wind and precipitation. The climate in the RFP area is typified by strong, often gusty winds. The stronger winds blow from the west and northwest, and occur more often during the winter months. The average annual precipitation (total moisture) for the area is 15 in (38 cm), of which 40 percent falls during the spring. Rainfall intensity varies from long, low-intensity frontal storms in the fall and early spring to short, intense cloudbursts in the late spring and summer months. Snowmelt can also generate high runoff in the area. Snowfall at the RFP averages 85 in/yr (216 cm/yr) (DOE, 1980). Climatology in the RFP vicinity is discussed in more detail in Subsection 2.1.4.4.

2.5.1.3.2 Contaminant Fate and Mobility in Air. Atmospheric resuspension of contaminated soil particles is the principal release mechanism affecting the plutonium and americium contamination in offsite surface soils. The same mechanism would exist for nonradioactive elements metals if they were present in the soils. Resuspension occurs as a result of wind action, and is often amplified by soil disturbance. The resuspension factor is defined as the ratio of the air concentration to soil concentration and is expressed as per meter (m^{-1}).

Resuspension factors for each known contaminated section of T2S, R69W are presented in Rockwell International's disclosure to the City of Broomfield regarding the remedy acreage (Past Remedy Report, Appendix E, Document E-8). These resuspension factors are:

- Section 6—1.5×10^{-9} m^{-1}
- Section 7—1.0×10^{-9} m^{-1}
- Section 18—1.8×10^{-9} m^{-1}.

The methodology behind the development of these values is given in SCS remedy recommendations (SCS, 1985). CDH developed similar values in the 1970s for quiescent, vegetated lands in the vicinity of the RFP. A further finding was that vehicular disturbance would change the average values to approximately 1×10^{-8} m^{-1} (CDH, 1976).

Once resuspended in air, soil particles can move long distances depending on wind velocity and turbulence. Smaller diameter particles will be carried longer distances; therefore, the size of the resuspended soil particles is critical in assessing their mobility. Previous studies have shown that the distribution of plutonium by soil particle sizes at the RFP was variable, indicating the association of plutonium with soil mineral phases of various sizes (McDowell and Whicker, 1978). The respirable percentage of suspended plutonium-contaminated soil particles in air (those with diameters less than 10 micrometers [μm]) has been estimated to be approximately 20 to 40 percent (Whicker et al., 1974). Because of the low settling velocities associated with such small particles, the particles can be transported relatively long distances by winds before settling.

2.5.1.3.3 **Contaminant Fate and Mobility in Groundwater**. As discussed in Subsection 2.5.1.2.1, the predominant form of plutonium expected in the RFP environs, PuO_2, is insoluble in water. Plutonium will tend to remain adsorbed to solid particles at pH values between 3 and 9 (Roxburgh, 1987). Plutonium can, however, undergo extremely limited dissolution in the pH range of environmental systems. The solid phase of PuO_2 is a colloidal polymer of neutral or positive charge. Such colloids can contain from 10^6 to 10^{10} atoms of plutonium (Andelman and Rozzell, 1970). Increasing pH tends to reduce the charge density of the polymer, and at pH > 9, it is expected that the colloids become negatively charged, decreasing the affinity of PuO_2 for soils and thus potentially increasing its mobility in surface water. The mobility of plutonium can also be increased through complexation with dissolved organic acid (DOE, 1991). Numerous measurements have shown that RFP groundwater tends to be neutral to slightly basic (typical pH is 7.5) and, therefore, the plutonium is not expected to be mobile in RFP groundwater.

The migration of plutonium ions in groundwater is retarded due to continuous distribution of plutonium between soil and water phases. The K_d values discussed in Subsection 2.5.1.2.1 indicate that plutonium will not leach readily to groundwater or migrate within groundwater.

2.5.1.3.4 Contaminant Fate and Mobility in Surface Water. The fate and transport of plutonium in drainage and reservoir sediments in the vicinity of the RFP has been evaluated and discussed (DOE, 1990). This document provides an evaluation of the potential transport and exposure pathways associated with the potential surface water runoff and soil erosion release mechanisms discussed below.

Surface runoff may erode contaminated surface soil and transport it as sediments to surface waters (e.g., streams and reservoirs). In stagnant surface waters (e.g., reservoirs and holding ponds), the suspended sediments settle to the bottom. Plutonium transported in this manner will tend to remain bound to the sediments during transport and after redeposition, as illustrated by the high K_d values associated with plutonium. As a result, bottom sediments will immobilize plutonium considerably. This strong adsorption has been demonstrated in laboratory studies of plutonium uptake by the clay-rich sediments typical of surface water impoundments near the RFP (CSU, 1974). High concentrations of dissolved organic carbon, carbonate, fluoride, chloride, or nitrate along with high percolation rates could potentially leach some of the plutonium in bottom sediments downward toward the water table. There is no evidence, however, that such a process is occurring in impoundments near the RFP. Plutonium concentrations in offsite reservoir sediments decrease to background levels at a depth of 8 to 12 inches (20 to 30 cm) in the reservoir sediment columns (Rockwell, 1984; Rockwell, 1985a). Furthermore, groundwater monitoring directly downgradient of onsite RFP holding ponds has not yielded a single detection of plutonium.

It has been demonstrated that density stratification of lake waters in summer months results in a reducing environment in deeper water. The distribution coefficient of plutonium in reducing environments is threefold to tenfold lower than in oxidizing conditions, indicating that plutonium mobility will increase somewhat. However, the K_d values for these waters are still very high (ANL, 1986).

Resuspension of plutonium from bottom sediments is also possible by organisms that disturb the sediments. The resuspended plutonium will eventually settle and again become part of the sediment.

2.5.1.3.5 Contaminant Fate and Mobility in Biota. Contaminants can be taken up from surface soils by biota either through mechanical spreading (tracking) or through physical incorporation of the contaminant into the biomass (bioconcentration and bioaccumulation). Tracking is considered an insignificant release mechanism when compared to the potential for wind or water erosion from surface soils.

Plutonium eroded from surface soils by wind or water can settle onto foliar surfaces. The magnitude of foliar retention will depend on the physical structure of the surface. Foliar contamination can be removed by weather or by dropping of plant parts (field loss).

Plutonium, which settles onto foliar surfaces or physically adsorbs to the surfaces of plants or zooplankton, can be taken up into the food chain. Plutonium on foliar surfaces may be absorbed metabolically by plants, or may pass from soil into the root systems of plants. A study using a water-soluble form of plutonium (not PuO_2) mixed into soil, however, demonstrated that significant uptake of plutonium does not occur in plants grown in the soil (specifically, the first crop of plants). The relative concentration factor expressed as concentration in dry plant material/concentration in dry soil was measured at less than 0.0001 in the study (Menzel, 1965). Similar values were obtained in a study involving a marsh estuary near Sellfield, England (Ham, 1989).

Plutonium taken up in the food chain by animals will not tend to bioconcentrate or bioaccumulate. The gastrointestinal absorption factor for PuO_2 listed by the International Commission on Radiation Protection (ICRP) is 1×10^{-5}, indicating that plutonium will not easily be absorbed through the intestine, but rather will pass through the intestine and be discharged as waste (ICRP, 1979). In adult animals less than 0.01 percent of ingested plutonium is absorbed from the intestine (ICRP, 1988). Past RFP studies, which have included bioassays of aquatic and terrestrial indicator plant and animal species, have found normal background concentrations of plutonium (EPA, 1971; CSU, 1974; CDH, 1990c).

2.5.1.4 Exposure Routes and Receptors

As illustrated in Figure 2-8, contaminants released from offsite surface soils can affect potential receptors through inhalation of airborne particles and through ingestion of or dermal contact with contaminated source or transport media. The most plausible exposure routes appear to be inhalation of plutonium-contaminated particles eroded from surface soil by wind and ingestion of plants with surficial contamination as a result of settled dust eroded from surface soil by wind. Potential human receptors include both residents of and visitors to the RFP area. The demographics of the RFP vicinity are discussed in Subsection 1.3.6. At the present time, both the Jefferson County and City of Broomfield remedy acreage at IHSS 199 are fenced and posted to prevent public access. Environmental receptors include biota (both flora and fauna) indigenous to the RFP environs, as addressed in Subsection 1.3.5.

2.5.1.5 Soils Conceptual Model Summary

Plutonium and americium are the only contaminants likely to exist in offsite surface soils as a result of RFP releases. Plutonium in offsite surface soils most likely exists as the thermodynamically stable solid PuO_2. Plutonium fate and mobility in the environment are controlled by its strong tendency to adsorb to clays, metal oxides, and organic matter in soils. Plutonium potentially can be released from surface soils into the transport media of air (by wind erosion) and surface water (by water erosion). Plutonium released into these media will tend to remain bound to the particles that transport it. Plutonium can also be taken up in the food chain by ingestion of plants with surficial PuO_2 contamination, but will not concentrate or accumulate in biota. Organic and inorganic contaminants will not be analyzed in soils because there have been no documented sources of release of significance that would allow dispersion via air to OU 3 (see Section 6.2).

Groundwater does not appear to be a viable transport medium for plutonium from offsite surface soils in the RFP area. Research and investigation of plutonium mobility at other locations have demonstrated that plutonium transport through unsaturated porous media is not significant (Andelman and Rozzell, 1970; Brookins, 1984; Kim et al., 1984; Shade et al., 1984; Silva et al., 1979; Staley et al., 1979). The reasons for this immobility appear to be the insolubility of plutonium dioxide and the strength with which it is adsorbed to fine-grained particles and organic matter in unsaturated porous media.

The most plausible exposure routes are inhalation of fugitive dust generated from surface soils and ingestion of plants onto which fugitive dust has settled.

2.5.2 Conceptual Model for Offsite Reservoirs and Drainages (IHSSs 200, 201, and 202)

The general conceptual model for offsite reservoirs and drainages is shown in Figure 2-15. The exposure pathways for IHSSs 200 through 202 are prioritized based on the Historical Information Summary and Preliminary Health Risk Assessment (DOE, 1991b) and are presented in Figure 2-16. The primary pathway, from a human health risk standpoint, is inhalation of reservoir/stream sediments dispersed to air through resuspension of fugitive dust. The secondary pathways are direct ingestion of sediments and surface water. The remaining pathways are believed to constitute a negligible risk to human health but are addressed in this work plan. The pathways were used to design the field sampling plan for OU 3 (see Section 6.0). Each numbered pathway is presented in detail in Appendix A. The pathways are referenced throughout the work plan to show how each pathway is being addressed. The various elements of the conceptual model are explained in the following subsections.

2.5.2.1 Historical Contamination Source

As shown in Figure 2-15, the RFP is considered the historical contamination source to the offsite reservoirs in the reservoir conceptual model. Based on information presented in Sections 1.0 and 2.0 on RFP geographical setting and environmental monitoring, the airborne, sediments, and surface water pathways are considered the only reasonable migration pathways that could transport contamination from the RFP to offsite reservoirs and drainages. Known and potential RFP sources of airborne and surface waterborne contamination via sediment transport to IHSSs 200, 201, and 202 are discussed in Subsections 2.2.3, 2.3.3 and 2.4.3, respectively. An understanding of the fate and mobility of the potential contaminants involved is critical in determining whether they could reasonably have impacted offsite reservoirs and drainages and, if so, whether they still exist in the reservoirs and drainages today.

A general discussion of fate and transport of organics and inorganics was presented in Subsection 2.5.1.1.

2.5.2.1.1 Radionuclides. Most of the studies performed to date at IHSSs 200, 201, and 202 have focused on plutonium contamination of reservoir sediments. It has been conclusively demonstrated that plutonium has been transported from the RFP via the surface water and air pathways and affected offsite reservoir and drainage sediments. Americium has also been detected in these sediments, indicating either direct surface waterborne or airborne transport from the RFP or in situ ingrowth from the plutonium in the sediments. Tritium is known to have been released to Great Western Reservoir through surface water. It is conceivable that surface waterborne or airborne transport of uranium associated with RFP activities to offsite drainages and reservoirs could occur.

2.5.2.1.2 Nonradioactive Contaminants. Nonradioactive contaminants discussed in Subsections 2.2.3, 2.3.3 and 2.4.3 include metals, VOCs, semivolatile organics, inorganic ions, and herbicides. Potential sources of airborne contaminants discussed in Subsection 2.5.1.1 for offsite surface soils also apply to the offsite reservoirs. Nonradioactive elements, VOCs, semivolatile organics, inorganic ions, and herbicides all could feasibly have been transported in surface water to

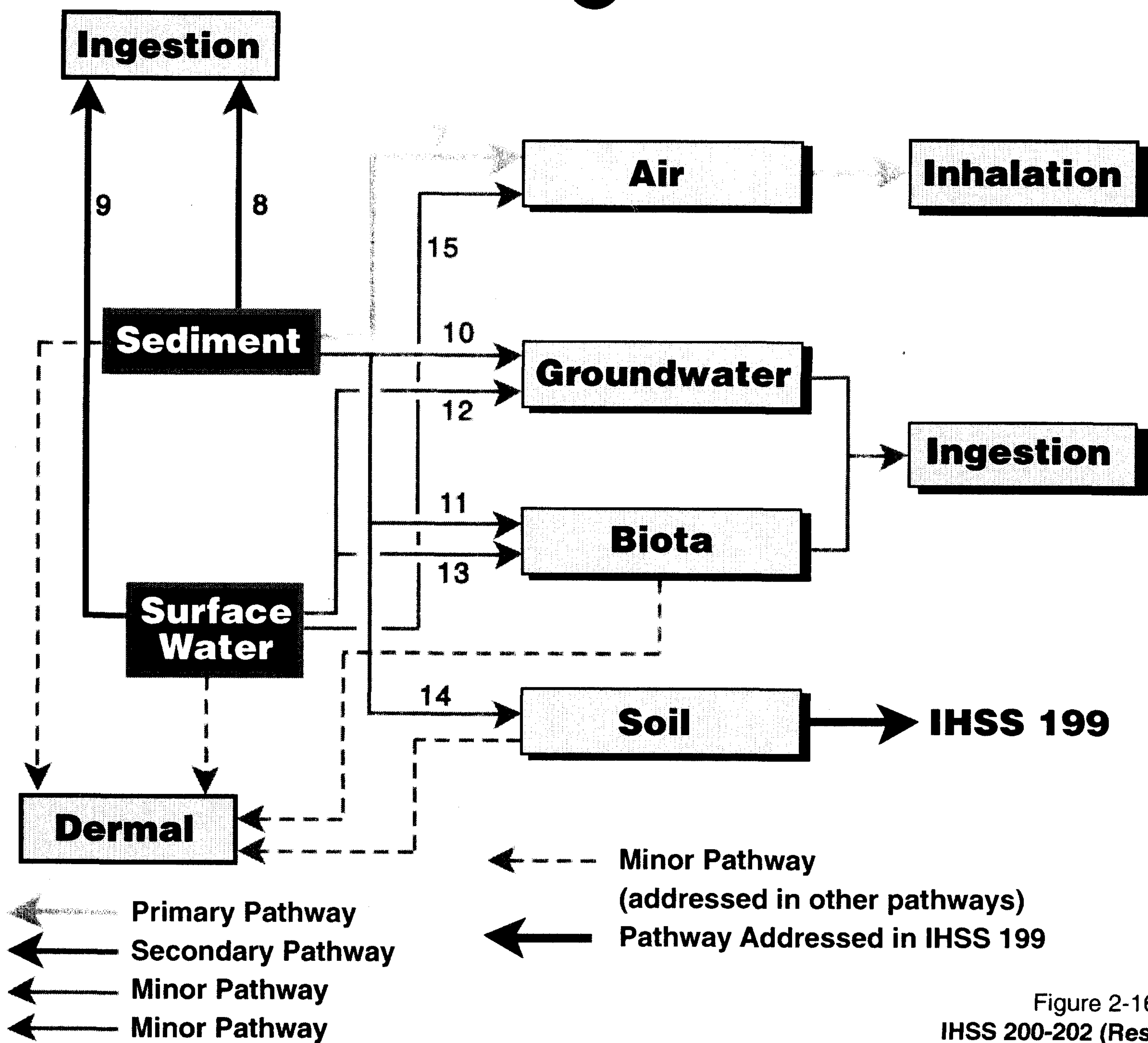


Figure 2-16
IHSS 200-202 (Reservoirs)
Human Health Priority Pathways

DRAWN BY	H. DOUVILLE	CHECKED BY	A. LANGE	10/25/91	DRAWING NUMBER	RF1019
	10/30/91	APPROVED BY	ALL	11/25/91		

the offsite drainages and reservoirs from either the RFP or surrounding agricultural and industrial sources. However, evaluations of analytical results from sampling stations along Indiana Street indicate these contaminants are not being detected (see Section 6.2).

2.5.2.2 Current Contaminant Source

Contaminated offsite drainage and reservoir water and sediments are considered the current contaminant source in the conceptual model (Figure 2-15). The following subsections focus on contaminant and source media characteristics that may affect contaminant transport from the source media.

2.5.2.2.1 Contaminant Characteristics. As discussed in Sections 2.1.3, 2.2.2, and 2.3.2, reservoir sediments at IHSSs 200, 201, and 202 have been shown to contain plutonium and its decay product, americium, in excess of expected background concentrations (as measured in Colorado Front Range reservoirs remote from the RFP). Concentrations of beryllium and of selected radionuclides other than plutonium and americium have also been characterized in these sediments, although to a much lesser extent than plutonium. Other potential RFP derived contaminants, including VOCs, semivolatiles, metals other than beryllium, inorganic ions, and herbicides, have been characterized in drainage and reservoir water through routine monitoring, but have not been measured in drainage and reservoir sediments.

Radionuclides

Plutonium and americium are the only RFP-derived radioactive contaminants known to exist in the offsite reservoirs and drainages. Plutonium concentrations in offsite drainage and reservoir sediments have been well-characterized through numerous sampling programs. Americium can be expected through ingrowth from plutonium and has been measured above background concentrations in offsite reservoir sediments (Battelle, 1981). Plutonium characteristics that may affect its fate and mobility in the environment are discussed in detail in Subsection 2.5.1.2.1. Much less information is available on the fate of americium in the environment. Americium is considered to be slightly more mobile in the environment than plutonium, but is insoluble under typical environmental conditions. Routine water quality monitoring in Great Western Reservoir and Standley Lake has indicated that the water in these reservoirs is not measurably impacted by the radionuclide contamination known to exist in the bottom sediments or by other potential radioactive contaminants, including uranium.

A release of tritium to IHSS 200 occurred in 1973. Environmental monitoring of water quality in the offsite drainages and reservoirs indicated that the tritium returned to normal background levels by 1976 and has remained at these levels. The potential impact of tritium on drainage and reservoir sediments has not been studied, but it is expected that tritium's extreme mobility in the environment would preclude concentration in sediments. Furthermore, natural radioactive decay (half life: 12.3 years) will have reduced any concentration of tritium since the 1973 release.

Vertical profiles of the plutonium-bearing layers or strata developed from offsite reservoir sediment cores have also shown that the plutonium-bearing strata in Great Western Reservoir and Standley Lake have been buried to varying depths by subsequent sedimentation. The four cores collected during the most recent Great Western Reservoir study (by Rockwell International in 1983) showed between 3-9 in (7.5 to 23 cm) of sediment overlying the plutonium-bearing layer. The depth of burial in two cores collected in 1984 by Rockwell International from Standley Lake varied from 6.3 to 8.7 in (16 to 22 cm). These cores were collected from deeper areas of the reservoirs, where greater sedimentation rates occur and the highest plutonium concentrations have been found to exist. Based on calculated sedimentation rates for the reservoirs, which vary from 0.1 in/yr (0.25 cm/yr) in shallow, near-shore areas to 1.4 in/yr (3.6 cm/yr) in deeper areas, it can be inferred that the plutonium-bearing layers in each reservoir could have been covered by an additional 0.7 inches (1.8 cm) of sediment in shallow areas and an additional 9.8 in (25 cm) of sediment in deeper zones in the 8 years since the Rockwell International studies were conducted.

Nonradioactive Contaminants

As discussed in Subsection 2.5.2.1, nonradioactive contaminants that could reasonably be expected to exist in the offsite drainages and reservoirs include VOCs, semivolatiles, metals, inorganic ions, and herbicides. Routine monitoring of surface water drainages at the RFP boundary by various agencies and municipalities has occasionally detected trace concentrations of VOCs, metals, inorganic ions, and herbicides. Because of the erosional nature of most drainages in the RFP area (Section 2.5.2.2.2), it is reasonable to expect that any contaminants in the drainages will eventually reach the reservoirs, unless surface water infiltration transports soluble contaminants to groundwater.

Because of the soluble nature of most VOCs, inorganic ions, and herbicides, it is reasonable to expect that these potential contaminants would not concentrate in bottom sediments, but rather would remain dissolved in surface water. Routine monitoring of Great Western Reservoir and Standley Lake have indicated that VOCs, inorganic ions, and herbicides have not measurably impacted reservoir water quality in these reservoirs. It is probable that nonradioactive metals would tend to precipitate in near neutral pH water, adsorb to suspended sediments in the water and settle out in reservoir bottom sediments in a manner similar to the radioactive metals plutonium and americium.

2.5.2.2.2 Sediment and Water Characteristics. Streams in the vicinity of the RFP are expected to be erosional, meaning that they will tend over time to transport their full sediment loads downstream rather than permanently depositing them within the drainage. If the sediment load eventually reaches an impoundment such as a holding pond or reservoir, the sediment will gradually settle out to form bottom sediments. Studies performed in the Environmental Assessment for the Standley Lake Diversion project indicate existing rates of erosion in the area of OU 3 appear to be relatively low. Average sediment yields published by the USGS for the RFP area range from 0.1 to 0.3 ton/acre/year (USGS, 1987). Section 2.5.1.3.4 discusses the fate and mobility of plutonium in sediments and surface water.

A distinction is made in Figure 2-15 between dry and saturated sediments because potential exposure pathways differ significantly for dry and saturated sediments. Because the water level in reservoirs fluctuates widely with varying supply and demand, particularly on a seasonal basis, sediments in near-shore and other shallow water areas may be exposed for long enough periods to dry. Dry sediments are potentially subject to a similar set of release mechanisms as that described in Subsection 2.5.1.3 for surface soils.

As discussed in Subsection 2.5.1.1, plutonium fate and mobility is partially influenced by pH and Eh. Surface water typically is characterized by oxidizing conditions and neutral or near-neutral pH. Under these conditions, plutonium will exist in the plus 4 oxidation state as solid plutonium hydroxide, $Pu(OH)_4$. Density stratification of lake waters in summer, however, can result in a reducing environment in deeper water. Under reducing conditions, the K_d of plutonium may be three- to ten-fold lower than under typical reservoir conditions, meaning that plutonium mobility may increase slightly. The magnitude of this increase is not significant, however, in terms of overall plutonium mobility (ANL, 1986).

The pH and Eh of environmental systems will influence the fate and mobility of most nonradioactive metals in a similar manner as plutonium.

2.5.2.3 Release Mechanisms and Transport Media

As shown in Figure 2-15, potential release mechanisms and transport media can combine in a variety of ways to transport contamination from the reservoirs to human and other biotic receptors. The identification of potential release mechanisms and transport media is not meant to imply that they will occur or be significant in the reservoirs. Preceding discussions have indicated that plutonium, americium, and possibly nonradioactive elements are the only contaminants likely to exist in offsite drainages and reservoirs, and that these contaminants may exist in measurable concentrations only in the drainage and reservoir sediments. The source medium in which the known and potential contaminants exist is a semiconsolidated mass buried in the sediment of each reservoir, and is in fact not expected to be readily available for release into the environment by any of the mechanisms described below.

Plutonium release mechanisms and behavior in transport media have been well-studied at the RFP and elsewhere, while specific information on the environmental fate and transport of americium are less abundant. As mentioned in Subsection 2.5.1.2.1, americium is suspected to be slightly more mobile than plutonium; but, for practical purposes, the two radionuclides behave similarly in the environment. For these reasons, the following subsections focus on plutonium.

2.5.2.3.1 Contaminant Fate and Mobility in Surface Water. Plutonium fate and mobility in surface water are addressed in Subsection 2.5.1.3.4. This discussion also applies to the general fate and mobility of potential nonradioactive elements in the offsite drainages and reservoirs.

As indicated previously, nonradioactive contaminants that have been detected in trace amounts in drainage water at the RFP boundary include VOCs, metals, inorganic ions, and herbicides. Because most of the ephemeral streams in the RFP area are losing streams (for example, streams which recharge groundwater), it is conceivable that soluble contaminants in surface water could be transported to groundwater by infiltration of surface water into the drainage bed.

2.5.2.3.2 Contaminant Fate and Mobility in Air. Plutonium fate and mobility in air are addressed in Subsection 2.5.1.3.2. This discussion will also apply to the general fate and mobility of potential nonradioactive metals in the offsite drainages and reservoirs.

2.5.2.3.3 Contaminant Fate and Mobility in Groundwater. No evidence has been observed in past studies of Great Western Reservoir or Standley Lake of solubilization and leaching of plutonium downward in the sediment column towards the groundwater table (Subsection 2.5.1.3.4). This lack of mobility results primarily from the strong tendency of plutonium to adsorb to clay and organic matter in the sediments. The discussion in Subsection 2.5.1.3.4 will also apply to the general fate and mobility of potential nonradioactive elements in the offsite drainages and reservoirs.

2.5.2.3.4 Contaminant Fate and Mobility in Biota. Plutonium fate and mobility in biota are addressed in Subsection 2.5.1.3.5.

2.5.2.4 Exposure Routes and Receptors

As illustrated in Figure 2-9, contaminants released from offsite drainages and reservoirs can affect potential receptors through inhalation of airborne particles and through ingestion of or dermal contact with contaminated source or transport media. The most plausible exposure routes appear to be inhalation of plutonium-contaminated particles eroded from exposed (dry) sediments by wind and ingestion of plants with surficial contamination as a result of settled dust eroded from exposed sediments by wind.

Potential human receptors include both residents of and visitors to the RFP area. The demographics of the RFP vicinity are discussed in Subsection 1.3.6. At the present time, Standley Lake (IHSS 201) and the surrounding area are used extensively for recreational purposes, including boating, fishing, and hiking. Great Western Reservoir (IHSS 200) is fenced and posted by the City of Broomfield to prevent public access. Both of these reservoirs are utilized as public water supplies. Standley Lake water is also used for irrigation of croplands, primarily in areas northeast of the reservoir. Mower Reservoir (IHSS 202) is used solely for cattle watering and irrigation and is located on private land.

Environmental receptors include biota (both flora and fauna) indigenous to the RFP environs, as addressed in Subsections 1.3.5 and 2.2.2.3.

2.5.2.5 Reservoir Conceptual Model Summary

Plutonium, americium, and possibly nonradioactive elements are the only contaminants likely to exist in offsite drainage and reservoir sediments as a result of RFP releases. Other potential contaminants, including VOCs, inorganic ions, and herbicides, may exist sporadically in drainage surface water, based on the results of environmental monitoring at the RFP boundary.

Plutonium in offsite drainages and reservoirs most likely exists as the thermodynamically stable solid $Pu(OH)_4$. Plutonium fate and mobility in the environment are controlled by its strong tendency to adsorb on clays, metallic oxides, and organic matter in soils. Plutonium potentially can be released from exposed (dry) reservoir sediments by wind erosion into the transport medium of air. Plutonium released into air will tend to remain bound to the particles that transport it. Plutonium can also be taken up in the food chain by ingestion of plants with surficial PuO_2 contamination, but has not been shown to concentrate or accumulate in biota.

Groundwater is not a viable transport medium for plutonium from offsite drainages and reservoirs in the RFP area. Results of past studies of Great Western Reservoir and Standley Lake have shown that the plutonium is effectively immobilized in the bottom sediments and is not being leached downward toward the water table. Incidental soluble contaminants in offsite drainage water may be transported to groundwater if the surface water infiltrates the drainage bed.

The most plausible exposure routes are inhalation of fugitive dust generated from exposed reservoir sediments and ingestion of plants onto which fugitive dust has settled.

3.0 ARARs

This section provides a preliminary identification of potential chemical-specific ARARs for surface water and groundwater at OU 3. Chemical-specific ARARs do not currently exist for soils. Under the terms of the 1985 Settlement Agreement for IHSS 199, the remedy action level was based upon the CDH special construction requirements standard for plutonium in soil of 0.9 pCi/g. The court-ordered agreement in IHSS 199 established a remediation goal of less than the CDH special construction requirements standard of 0.9 pCi/g. However, it is stated in the Settlement Agreement that adoption of the CDH standard is not meant to imply concurrence between the lawsuit parties on the reasonableness, appropriateness, or applicability of the standard as an action level for the remedy. As the remedial investigation proceeds, information will become available from the risk assessment, that will allow a determination of acceptable contaminant concentrations in soils to protect human health and the environment.

The summary of possible ARARs presented in this section is based on current federal and state health and environmental statutes and regulations and the chemicals suspected to be present at OU 3. The rationale for the chemicals suspected to be present at OU 3 is presented in Subsection 6.2. The preliminary identification and examination of potential ARARs provide for the use of appropriate analytical detection limits during the RFI/RI. As data become available during the RFI/RI, specific ARARs will be proposed for OU 3. If conducted, the CMS Feasibility Study (FS) report will further address chemical-specific ARARs as well as action- and location-specific ARARs in the development and evaluation of remedial alternatives.

3.1 THE ARARs BASIS

The basis for ARARs is cited in Section 121(d) for CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires that Superfund-financed, enforcement, and federal facility remedial actions comply with applicable or relevant and appropriate federal laws or promulgated state laws, whichever is more stringent. For the purposes of identification and notification of promulgated state standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable (NCP, 40 CFR 300.400[g][4]). CDH Water Quality Control Commission (WQCC) groundwater standards are to-be-considered (TBC) since they are not yet enforceable.

3.2 THE ARAR PROCESS

A screening and analysis process will be used to determine the potential ARARs to be applied to OU 3. The analysis will address compliance with chemical-, location-, and action-specific ARARs in accordance with the NCP. The screening process will consider relevant and appropriate requirements in the same manner as applicable requirements. When more than one ARAR is identified, the most stringent ARAR will be used.

The first step in identifying potential ARARs will occur after the initial scoping and site characterization and will involve the analysis of the chemicals suspected to be present at the site and any location-specific characteristics at the site. Once the chemicals have been identified, the presence or absence of chemical-specific ARARs will be determined.

Chemical-specific ARARs are derived primarily from federal and state health and environmental statutes and regulations, including the following:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater

- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water

- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94)—applied to groundwater

- CDH surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.29, Final Rule Effective March 30, 1990)--applied to surface water

- CDH WQCC statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11, anticipated to be finalized in November 1991)--applied to groundwater as TBC

A summary of chemical-specific standard or potential ARARs based on the above regulations and contaminants that may be found at OU 3 is presented in Table 3-1, Groundwater Quality Standards; Table 3-2, Federal Surface Water Quality Standards; and Table 3-3, State Surface Water Quality Standards. These potential chemical-specific ARARs and accompanying regulations will be screened to determine their jurisdictional requirements and applicability to OU 3. If the requirements are not applicable, they will be further screened to determine whether they are relevant and appropriate to the particular site-specific conditions at OU 3. Where ARARs do not exist for a particular chemical, or where existing ARARs are not protective of human health or the environment, TBC criteria, such as guidances, proposed standards, and advisories will be evaluated for use. Where ARARs and TBCs are not available or are less than laboratory practical quantitation limits (PQLs), PQLs will be used to measure compliance with ARARs and TBCs. Standards identified as potential ARARs, as well as TBC criteria, will be analyzed according to the procedures outlined in the NCP, <u>CERCLA Compliance with Other Laws Manual</u> (EPA 1989b), <u>Risk Assessment Guidance for Superfund Human Health Evaluation Manual, Volume 1</u> (EPA 1989c), and <u>Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites</u> (EPA 1988b).

3.2.1 ARARs

"Applicable requirements," as defined in 40 CFR 300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that

TABLE 3-1

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) GROUNDWATER QUALITY STANDARDS (µg/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (3)	PQL MDL	Method (4)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Bicarbonate	A	10	E310.1													
Carbonate	A	10	E310.1													
Chloride	A	5	E325	250,000 *							250,000					
Chlorine	A	1000	E4500													
Fluoride	A	5	E340	4,000; 2,000*		4,000				4,000		2,000				
N as Nitrate	A	5	E353.1	10,000			10,000			10,000						
N as Nitrate+Nitrite	A	5	E353.1		10,000		10,000					100,000				
N as Nitrite	A	5	E354.1		1,000		1,000			1,000		10,000				
Sulfate	A	5	E375.4	250,000*							250,000					
Sulfide	A															
Sulfur	E	100,000	E600													
Dissolved Oxygen	FP	0.5	SM4500													
pH	FP	0.1	E150.1	6.5–8.5 *							6.5–8.5	6.5–8.5				
Specific Conductance	FP	1	E120.1													
Temperature	FP															
Boron	I	5	E6010									750				
Total Dissolved Solids	I	10	E160.1	500,000*									400,000 (1)			
Americium (pCi/l)	R														0.05	0.05
Americium 241 (pCi/l)	R	0.01														
Gross Alpha (pCi/l)	R	2		15 (8)						15					7	11
Gross Beta (pCi/l)	R	4		50 (4 mrem/yr)						4 mrem/yr					5	19
Plutonium 238+239+240 (pCi/l)	R	0.01							15 (2)							
Plutonium (pCi/l)	R														0.05	0.05
Uranium 233+234 (pCi/l)	R															
Uranium 235 (pCi/l)	R	0.6														
Uranium 238 (pCi/l)	R	0.6														
Uranium (Total) (pCi/l)	R														5	10

TABLE 3-1

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) GROUNDWATER QUALITY STANDARDS (µg/l) (Concluded)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (3)	PQL MDL	Method (4)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek

EXPLANATION OF TABLE

* = secondary maximum contaminant level; TBCs

CDH = Colorado Department of Health
CLP = Contract Laboratory Program
EPA = Environmental Protection Agency
pCi/l = picocuries per liter
PQL = Practical Quantitation Limit
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
TIC = Tentatively Identified Compound
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
WQCC = Water Quality Control Commission

(1) TDS standard – see Table 4 in (d); standard is 400 mg/l or 1.25 times the background level, whichever is least restrictive
(2) radionuclide standards – see sec. 3.11.5(c)2 in (d)
(3) type abbreviations are: A=anion; C=cation; E=element; FP=field parameter; I=indicator; R=*radionuclide;*
(4) method abbreviations are: E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TIC in CV;
d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.
(7) Standard is below (more stringent than) PQL, therefore PQL is standard.
(8) Value for gross alpha excludes uranium.

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of 5/1990)
(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective July 30, 1992 (56 FR 3526; 1/30/1991)
(c) NCP, 40 CFR 300; NCP Preamble 55 FR 8764; CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006, August 1988
(d) CDH/Water Quality Control Commission, The Basic Standards for Ground Water, 3.11.0 (5 CCR 1002-8) 1/5/1987 amended 9/11/1990
(e) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective January 1, 1993 (56 FR 30266; 7/1/1991)
(f) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/91) effective 11/6/91.
(g) CDH/Water Quality Control Commission, Classifications and Water Quality Standards for Ground Water, 3.12.0 (3/5/1991).

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (µg/l)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c): Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c): Chronic Value	CWA AWQC for Protection of Human Health TBCs (c): Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c): Fish Consumption Only
Bicarbonate	A	10	E310.1								
Carbonate	A	10	E310.1								
Chloride	A	5	E325	250,000*				860,000(e)	230,000(e)		
Chlorine	A	1000	E4500					19	11		
Flouride	A	5	E340	4,000; 2,000*		4,000					4,000
N as Nitrate	A	5	E353.1	10,000			10,000			10,000	
N as Nitrate+Nitrite	A	5	E353.1		10,000		10,000				
N as Nitrite	A	5	E354.1		1,000		1,000				
Sulfate	A	5	E375.4	250,000*							
Sulfide	A										
Ammonia as N	C	5	E350					Criteria are pH	and temperature	dependent – see	criteria document
Sulfur	E	100,000	E600								
Dissolved Oxygen	FP	0.5	SM4500					5,000			
pH	FP	0.1	E150.1	6.5-8.5 *					6.5-9		
Specific Conductance	FP	1	E120.1								
Temperature	FP							SS	SS		
Boron	I	5	E6010								
Total Dissolved Solids	I	10	E160.1	500,000*				SS	SS	250,000	
Aluminum	M	200	CT		50 to 200*			750	87		
Antimony	M	60	CT					9,000	1,600	146	45,000
Arsenic	M	10	CT	50						.0022	.0175
Arsenic III	M							360	190		
Arsenic V	M							850	48		
Barium	M	200	CT	1,000	2,000 (f)		2,000 (f)			1,000	
Beryllium	M	5	CT					130	5.3	.0068**	.117**
Cadmium	M	5	CT	10	5		5	3.9 (3)	1.1 (3)	10	
Calcium	M	5,000	CT								
Cesium	M	1,000	NC								

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c) Acute Value	Chronic Value	CWA AWQC for Protection of Human Health TBCs (c) Water and Fish Ingestion	Fish Consumption Only
Chromium	M	10	CT	50	100		100				
Chromium III	M	5	SW8467196					1,700	210	170,000	3,433,000
Chromium VI	M	10	E218.5					16	11	50	
Cobalt	M	50	CT								
Copper	M	25	CT	1,000*			1,300 (f)	18 (3)	12 (3)		
Cyanide	M	10	CT					22	5.2	200	
Iron	M	100	CT	300 *					1,000	300	
Lead	M	5	CT	50			0 (g)	82 (3)	3.2 (3)	50	
Lithium	M	100	NC								
Magnesium	M	5000	CT								
Manganese	M	15	CT	50 *						50	100
Mercury	M	0.2	CT	2	2		2	2.4	0.012	0.144	0.146
Molybdenum	M	200	NC								
Nickel	M	40	CT					1,400 (3)	160 (3)	13.4	100
Potassium	M	5000	CT								
Selenium	M	5	CT	10	50		50	20 (d)	5 (d)	10	
Silver	M	10	CT	50	100 *			4.1 (3)	0.12	50	
Sodium	M	5000	CT								
Strontium	M	200	NC								
Thallium	M	10	CT					1,400 (1)	40 (1)	13	48
Tin	M	200	NC								
Titanium	M	10	E6010								
Tungsten	M	10	E6010								
Vanadium	M	50	CT								
Zinc	M	20	CT	5,000 *				120 (3)	110 (3)		
Simazine	H		e								
Atrazine	H		e		3		3				
Americium (pCi/l)	R										

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c): Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c): Chronic Value	CWA AWQC for Protection of Human Health TBCs (c): Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c): Fish Consumption Only
Americium 241 (pCi/l)	R	0.01									
Gross Alpha (pCI/l)	R	2		15 (8)							15
Gross Beta (pCi/l)	R	4		50 (4 mrem/yr)							
Plutonium (pCi/l)	R										
Plutonium 238+239+240 (pCi/l)	R	0.01									
Uranium 233+234 (pCi/l)	R										
Uranium 235 (pCi/l)	R	0.6									
Uranium 238 (pCi/l)	R	0.6									
Uranium (total) (pCi/l)	R										
1,1,1-Trichloroethane	V	5	CV	200		200				18,400	1,030,000
1,1,2,2-Tetrachloroethane	V	5	CV						2,400	0.17**	10.7 **
1,1,2-Trichloroethane	V	5	CV						9,400	0.6**	41.8 **
1,1-Dichloroethane	V	5	CV								
1,1-Dichloroethene	V	5	CV	7		7					
1,2-Dichloroethane	V	5	CV	5		0		118,000	20,000	0.94**	243 **
1,2-Dichloroethene (cis)	V		a		70		70				
1,2-Dichloroethene (total)	V	5	CV								
1,2-Dichloroethene (trans)	V		a		100		100				
1,2-Dichloropropane	V	5	CV		5		0	23,000	5,700		
1,3-Dichloropropene (cis)	V	5	CV					6,060	244 (1)	87	14,100
1,3-Dichloropropene (trans)	V	5	CV					6,060	244 (1)	87	14,100
2-Butanone	V	10	CV								
2-Hexanone	V	10	CV								
4-Methyl-2-pentanone	V	10	CV								
Acetone	V	10	CV								
Acrylonitrile	V		c					7,500	2,600	0.058	0.65
Benzene	V	5	CV	5		0		5,300		0.66**	40 **
Bromodichloromethane	V	5	CV								
Bromoform	V	5	CV								

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Bromomethane	V	10	CV								
Carbon Disulfide	V	5	CV								
Carbon Tetrachloride	V	5	CV	5		0		35,200 (1)		0.4**	6.94 **
Chlorinated Benzenes	V	10	CV/CS					250 (1)	50 (1)		
Chlorobenzene	V	5	CV/CS		100		100				
Chloroethane	V	10	CV								
Chloroform	V	5	CV	Tot THM<100 (2)				28,900 (1)	1,240 (4)	0.19 **	15.7 **
Chloromethane	V	10	CV								
Dibromochloromethane	V	5	CV								
Dichloroethenes	V							11,600 (1)		0.033**	1.85 **
Ethyl Benzene	V	5	CV		700		700	32,000 (1)		1,400	3,280
Ethylene Dibromide	V		d		0.05		0				
Ethylene Oxide	V										
Halomethanes	V			100				11,000 (1)		0.19**	15.7 **
Methylene Chloride	V	5	CV								
Pyrene	V	10	CS								
Styrene	V	5	CV		100		100				
Tetrachloroethanes	V	5	CV					9,320 (1)			
Tetrachloroethene	V	5	CV		5		0	5,280 (1)	840 (1)	0.80**	8.85 **
Toluene	V	5	CV		1,000		1,000	17,500 (1)		14,300	424,000
Trichloroethanes	V	5	CV					18,000 (1)			
Trichloroethene	V	5	CV	5		0		45,000 (1)	21,900 (1)	2.7 **	80.7 **
Vinyl Acetate	V	10	CV								
Xylenes (total)	V	5	CV		10,000		10,000				

EXPLANATION OF TABLE

* = secondary maximum contaminant level, TBCs

** = Human health criteria for carcinogens reported for three risk levels. Value presented is the 10–5 risk level.

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (μg/l) (Continued)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only

AWQ = Ambient Water Quality Criteria
CLP = Contract Laboratory Program
CWA = Clean Water Act
EPA = Environmental Protection Agency
pCi/l = picocuries per liter
PQL = Practical Quantitation Level
SDW = *Safe Drinking Water Act*
SS = Species Specific
TAL = Target Analyte List
THM = Total Trihalomethanes
TIC = Tentatively Identified Compound
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis

(1) criteria not developed; value presented is lowest observed effects level (LOEL)
(2) total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane
(3) hardness dependent criteria
(4) pH dependent criteria (7.8 pH used)
(5) standard is not adequately protective when chloride is associated with potassium, calcium, or magnesium, rather than sodium.
(6) type abbreviations are: A=anion; C=cation; FP=field parameter; H=herbicide; I=indicator; M=metal; R=radionuclide; V=volatile
(7) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TIC in CS; c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.
(8) Value for gross alpha excludes uranium

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990). Segment 4 MCLs are ARAR; Segment 5 MCLs are TBC; all MCLGs are TBC.
(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142 and 143, Final Rule (56 FR 3526; 1/30/91) effective July 30, 1992.
(c) EPA, Quality Criteria for Protection of Aquatic Life, 1986
(d) EPA, National Ambient Water Quality Criteria for Selenium - 1987
(e) EPA, National Ambient Water Quality Criteria for Chloride - 1988

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) FEDERAL SURFACE WATER QUALITY STANDARDS (µg/l) (Concluded)

Parameter	Type (6)	PQL MDL	Method (7)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only

(f) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, and 143, Final Rule (56 FR 30266; 7/1/1991) effective 1/1/1993.
(g) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/1991) effective 11/6/1991.

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (µg/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B	Table C Aquatic Life		Tables I,II,III (1)				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio-nuclide	Stream Segment Table (8)		Table 2 Radionuclides	
				Carcinogens/ Noncarcin-ogens (2)			Aquatic Life		Agricul-tural Standard (3)	Domestic Water Supply (6)									
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)			Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
Bicarbonate	A	10	E310.1																
Carbonate	A	10	E310.1																
Chloride	A	5	E325							250,000						3	3		
Chlorine	A	1000	E4500		3	3										3	3		
Fluoride	A	5	E340							2,000									
N as Nitrate	A	5	E353.1						100,000	10,000						10,000	10,000		
N as Nitrate+Nitrite	A	5	E353.1						100,000	10,000									
N as Nitrite	A	5	E354.1				SS	SS	10,000	1,000						1,000	1,000		
Sulfate	A	5	E375.4							250,000						250,000	250,000		
Sulfide	A							2		50									
Ammonia as N	C	5	E350				620	60		5,000						620	60		
				(13)									(13)						
Sulfur	E	100,000	E600													2.0	2.0		
Dissolved Oxygen	FP	0.5	SM4500				5,000	5,000	3,000	3,000						5,000	5,000		
pH	FP	0.1	E150.1				6.5-9.0	6.5-9.0		5.0-9.0						6.5-9	6.5-9		
Specific Conductance	FP	1	E120.1																
Temperature	FP						30 degrees	30 degrees											
Boron	I	5	E6010						750							750	750		
Total Dissolved Solids	I	10	E160.1																
Aluminum	M	200	CT				950	150											
Antimony	M	60	CT																
Arsenic	M	10	CT				360	150	100	50						50			
Arsenic III	M																		
Arsenic V	M																		
Barium	M	200	CT							1,000									
Beryllium	M	5	CT						100										
Cadmium	M	5	CT				TVS	TVS	10	10						TVS	TVS		
Calcium	M	5,000	CT																
Cesium	M	1,000	NC																
Chromium	M	10	CT																
Chromium III	M	5	SW8467196				TVS	TVS	100	50						50			
Chromium VI	M	10	E218.5				16	11	100	50						TVS	TVS		
Cobalt	M	50	CT																
Copper	M	25	CT				TVS	TVS	200							TVS	TVS		
Cyanide	M	10	CT				5	5	200	1,000						5	5		
Iron	M	100	CT					1,000		300 (dis)							300 (5)		
Lead	M	5	CT				TVS	TVS	100	50						TVS	TVS		

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (6)	Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)			Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
Lithium	M	100	NC																
Magnesium	M	5000	CT																
Manganese	M	15	CT					1,000	200	50 (dis)							50 (5)		
Mercury	M	0.2	CT				2.4	0.1		2.0							0.01		
Molybdenum	M	200	NC																
Nickel	M	40	CT				TVS	TVS	200							TVS	TVS		
Potassium	M	5000	CT																
Selenium	M	5	CT				135	17	20	10						10			
Silver	M	10	CT				TVS	TVS		50						TVS	TVS		
Sodium	M	5000	CT																
Strontium	M	200	NC																
Thallium	M	10	CT					15											
Tin	M	200	NC																
Titanium	M	10	E6010																
Tungsten	M	10	E6010																
Vanadium	M	50	CT																
Zinc	M	20	CT				TVS	TVS	2,000	5,000						TVS	TVS		
Simazine	H		e											4			4		
Atrazine	H		e											3			3		
Americium (pCi/l)	R																		
Americium 241 (pCi/l)	R	0.01																0.05	0.05
Gross Alpha (pCi/l)	R	2													30				
Gross Beta (pCi/l)	R	4																7	11
Plutonium (pCi/l)	R																	5	19
Plutonium 238+239+240 (pCi/l)	R	0.01		15 (6)														0.05	0.05
Uranium 233+234 (pCi/l)	R														15				
Uranium 235 (pCi/l)	R	0.6																	
Uranium 238 (pCi/l)	R	0.6																	
Uranium (Total) (pCi/l)	R						TVS	TVS							40			5	10
1,1,1-Trichloroethane	V	5	CV	200									200						
1,1,2,2-Tetrachloroethane	V	5	CV			2,400								0.17			0.17		
1,1,2-Trichloroethane	V	5	CV	28		9,400							28	0.60			0.60		
1,1-Dichloroethane	V	5	CV																
1,1-Dichloroethene	V	5	CV	7									7						
1,2-Dichloroethane	V	5	CV	5	118,000	20,000							5						

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B	Table C		Tables I,II,III (1)				Organics (12)		Tables A,B	Table C	Table D	Stream Segment Table (8)		Table 2 Radionuclides	
				Carcinogens/ Noncarcin-ogens (2)	Aquatic Life		Aquatic Life		Agricul-tural Standard (3)	Domestic Water Supply (6)			(2)	Fish & Water Ingestion	Radio-nuclide				
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)			Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
1,2-Dichloroethene (cis)	V		a	70									70						
1,2-Dichloroethene (total)	V	5	CV																
1,2-Dichloroethene (trans)	V		a	70									70						
1,2-Dichloropropane	V	5	CV	0.56 (13)	23,000	5,700							0.56 (13)						
1,3-Dichloropropene (cis)	V	5	CV		6,060	244													
1,3-Dichloropropene (trans)	V	5	CV		6,060	244													
2-Butanone	V	10	CV																
2-Hexanone	V	10	CV																
4-Methyl-2-pentanone	V	10	CV																
Acetone	V	10	CV																
Acrylonitrile	V		c		7,550	2,600								0.058			0.058		
Benzene	V	5	CV	5	5,300								5						
Bromodichloromethane	V	5	CV																
Bromoform	V	5	CV																
Bromomethane	V	10	CV																
Carbon Disulfide	V	5	CV																
Carbon Tetrachloride	V	5	CV	5	35,200								5						
Chlorinated Benzenes	V	10	CV/CS																
Chlorobenzene	V	5	CV/CVS	300									300						
Chloroethane	V	10	CV																
Chloroform	V	5	CV	Tot THM <100 (4)	28,900	1,240							Tot THM <100 (4)	0.19			0.19		
Chloromethane	V	10	CV																
Dibromochloromethane	V	5	CV																
Dichloroethenes	V																		
Ethyl Benzene	V	5	CV	680	32,000								680						
Ethylene Dibromide	V		d																
Ethylene Oxide	V																		
Halomethanes	V			100									100	0.19			0.19		
Methylene Chloride	V	5	CV																
Pyrene	V	10	CS																
Styrene	V	5	CV																
Tetrachloroethanes	V	5	CV											0.8			0.8		
Tetrachloroethene	V	5	CV	10	5,280	840							10						
Toluene	V	5	CV	2,420	17,500								2,420						
Trichloroethanes	V	5	CV																
Trichloroethene	V	5	CV	5	45,000	21,900							5						
Vinyl Acetate	V	10	CV																
Xylenes (Total)	V	5	CV																

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (µg/l) (Continued)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
							Aquatic Life												
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek

EXPLANATION OF TABLE

CLP = Contract Laboratory Program
CDH = Colorado Department of Health
dis = dissolved
EPA = Environmental Protection Agency
pCi/l = picocuries per liter
PQL = Practical Quantitation Level
SS = species specific
TAL = Target Analyte List
THM = Total Trihalomethanes
TIC = Tentatively Identified Compound
TVS = Table Value Standard (hardness dependent), see Table III in (a)
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis
WQCC = Water Quality Control Commission

(1) Table I = physical and biological parameters
Table II = inorganic parameters
Table III = metal parameters
Values in Tables I, II, and III for recreational uses, cold water biota and domestic water supply are not included.
(2) In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA
(3) All are 30-day standards except for nitrate+nitrite
(4) Total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane
(5) Lowest value given: dissolved or total recoverable
(6) Ammonia, sulfide, chloride, sulfate, copper, iron, manganese, and zinc are 30-day standards, all others are 1-day standards
(7) Segment 5 standards are goals
(8) Includes Table 1: Additional Organic Chemical Standards (chronic only)
(9) See section 3.1.11 (f)(2) in (a)
(10) type abbreviations are: A=anion; C=cation; FP=field parameter; H=herbicide; I=indicator; M=metal; R=radionuclide; V=volatile
(11) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.
(12) See Section 3.8.5 (2)(a) in (b)
(13) Standard is below (more stringent than) PQL, therefore PQL is standard.

(a) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974; amended 9/30/1989 (ARAR)

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (OCTOBER 1, 1991) STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (μg/l) (Concluded)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek

(Envrionmental Reporter 726:1001-1020:6/1990)

(b) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981; amended 2/15/1990.
Basin-wide standards are ARAR; Site-specific standards are TBC.

are more stringent than federal requirements may be applicable." "Relevant and appropriate requirements," also defined in 40 CFR 300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility stringent laws, that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate." The most stringent promulgated standards are applied as ARAR (Preamble to NCP, 55 FR 8741).

3.2.2 TBCs

In addition to applicable or relevant and appropriate requirements, advisories, criteria, or guidance may be identified as TBC for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category consists of advisories, criteria, or guidance developed by EPA, other federal agencies, or states that may be useful in developing remedies. Use of TBCs is discretionary rather than mandatory, as is the case with ARARs.

3.2.3 ARAR Categories

In general, there are three categories of ARARs:

1. Ambient or chemical-specific requirements
2. Location-specific requirements
3. Performance, design, or other action-specific requirements.

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process. Initially, during the RI work plan stage, probable chemical-specific ARARs may be identified, usually based on a limited amount of data. Chemical-specific ARARs at this point have meaning only in that they may be used to ensure appropriate detection limits have been established so that data collected in the RI will be amendable for comparison to ARAR standards. Chemical-specific ARARs may be deleted if they are found to be inappropriate any time in the RFI/RI process. Deletion of chemical-specific ARARs will be based on analytical information obtained from sampling at OU 3. It is also appropriate to identify location-specific ARARs early in the RI process so that information may be gathered to determine if restrictions may be placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location.

As discussed in the introductory paragraphs to Section 3.0, detailed location-specific ARARs will be proposed in the RFI/RI Report. Identification of action-specific ARARs and remediation goals is part of the Feasibility Study process and will be addressed in the CMS/FS Report, if a CMS/FS Report is necessary.

For the proper management of investigation-derived wastes, as required in the IAG, Attachment 2, Statement of Work, Section IV, DOE has developed SOPs for field investigation activities. All waste generated by the various investigations conducted at RFP will follow the SOPs. The SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities. This approach is consistent with EPA policy as provided in the "Draft Guide to Management of Investigation–Derived Waste" (U.S. EPA 1991b).

3.2.4 Remedial Action

CERCLA §121 specifically requires attainment of ARARs. Moreover, as explained in the preamble to the NCP (55 FR 8741), in order to attain ARARs, a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs. Furthermore, CERCLA requires that the remedies selected attain ARARs and be protective of human health and the environment. Consequently, remedial action objectives based on ARARs require modification as new information and data are collected in the RFI/RI, including the BRA (to be conducted), when ARARs are not available or are determined to be inadequate for protection of human health and the environment.

3.2.5 Remediation Goals

Development of remediation goals is actually a portion of the overall development of remedial action objectives, which ultimately define the required endpoint of the selected remedial action. As stated in the preamble to the NCP (55 FR 8713), "remedial action objectives are the more general description of what the remedial action will accomplish. Remediation goals are a subset of remedial action objectives and consist of medium-specific or operable unit-specific chemical concentrations that are protective of human health and the environment and serve as goals for the remedial action. The remedial action objectives ... should specify: (1) the contaminants of concern, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure medium (such as preliminary remediation goals)." According to 40 CFR 300.430 (e)(2)(i), "Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following:

- ARARs (chemical-specific) including
  - Acceptable exposure levels for systemic toxicants
  - Acceptable exposure levels for known or suspected carcinogens
  - Technical limitations (such as detection limits)
  - Uncertainty factors
  - Other pertinent information

- MCLGs (or Maximum Contaminant Levels–MCLs–where MCLGs are zero or where MCLGs are not relevant and appropriate), where relevant and appropriate

- Acceptable exposure levels where multiple contaminants or multiple exposure pathways will cause exposure at ARAR levels will result in cumulative risk in excess of 10^{-4}

- CWA Water Quality Criteria, where relevant and appropriate

- A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii)

- Environmental evaluation, performed to assess specific threats to the environment.

Once a remedial action alternative is formally selected, all chemical-, location-, and action-specific ARARs are defined in final form. If it is found that the most suitable remedial alternative does not meet an ARAR, the NCP, at 40 CFR 300.430 (f)(1)(ii)(C), provides for waivers of ARARs under certain circumstances, such as technical impracticability, risk, or inconsistent application of state requirements. From this point, the alternative becomes the final remedy as it is incorporated into the Record of Decision (ROD). Once the final ROD has been signed, measurements may be modified only when they are determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment (40 CFR 300.430[f][1][ii]).

4.0 RFI/RI TASKS

This section describes the tasks to be implemented during the course of the RFI/RI. The specific tasks are designed to provide information to meet the DQOs that are identified in Section 5.0 of this document, titled Data Needs and Data Quality Objectives. The following tasks are described in this section:

- Task 1–Project Planning/Management
- Task 2–Community Relations
- Task 3–Field Investigation
- Task 4–Sample Analysis and Data Validation
- Task 5–Data Evaluation
- Task 6–Baseline Risk Assessment and Environmental Evaluation
- Task 7–Treatability Studies
- Task 8–Remedial Investigation Report
- Task 9–Remedial Alternatives Development/Screening
- Task 10–Detailed Analysis of Remedial Alternatives.

The tasks presented above are 10 of the 14 standard tasks that have been identified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a). The four standard tasks not included are Task 11–Feasibility Study Reports, Task 12–Post-RI/FS Support, Task 13–Enforcement Support, and Task 14–Miscellaneous Support. Task 11 is included as part of Task 10 in this document. The remaining tasks are not relevant to the scope of this work plan.

4.1 TASK 1—PROJECT PLANNING/MANAGEMENT

The objective of project planning/management during the performance of the OU 3 RFI/RI is to direct and document project activities so that data collected and evaluations conducted meet the goals and objectives of the Work Plan. Specific project management activities that will occur throughout the RFI/RI include the following:

- Meetings
- Cost and Schedule Control
- Data Management
- Progress Reports.

These activities will be conducted to identify potential problems with sufficient time to make necessary corrections and keep the project focused on its objectives, on schedule, and within budget.

The project planning activities to be conducted early in the project include:

- Review of existing information
- Site surveys
- Access agreements.

The first two planning activities are discussed briefly within this subsection and in more detail in Section 6.0.

4.1.1 Review of Existing Information

Existing site information will be reviewed to facilitate project planning. Aerial photographs will be reviewed to identify undisturbed areas. These areas will aid in refining soil and sediment sampling locations. Data collected for reservoirs will also be reviewed to obtain information about them such as hydrologic characteristics and historic low levels. This information will be used to refine sediment and air sampling locations.

In addition, data collected since the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 Sites 200, 201, 202 (DOE, April 1991b) and the Final Past Remedy Report Operable Unit No. 3–IHSS 199 (DOE, April 1991a) were developed will be evaluated. The data useability will be evaluated following the requirements set forth in the Guidance for Data Useability in Risk Assessment (EPA, 1990b). The data are anticipated to include analytical results from soil and water samples collected by municipalities, collected from other RFP OU field investigations, and collected by RFP monitoring programs.

4.1.2 Site Surveys

Site surveys will be performed as part of project planning. The site surveys will including touring OU 3 and taking detailed notes on and photographs of vegetation and biota present and of areas where contamination could accumulate. Such areas include snow accumulation areas and wetlands. This information will also be used to refine the field investigations described in Subsection 4.3 and Section 6.0 of this document.

4.1.3 Access Agreements

Access agreements will be obtained to perform the RFI/RI. Tax assessment records will be reviewed to determine the property owners' names and addresses. This information will be provided to EG&G, who will secure the access agreements, if needed.

4.2 TASK 2–COMMUNITY RELATIONS

The information contained in this section is summarized from (DOE, 1990b). In accordance with the IAG, the Communications Department at Rocky Flats has developed a Plant-wide Community Relations Plan (CRP) to develop an interactive relationship with the public relating to ER activities.

A Draft Community Relations Survey Plan has been completed and forwarded to EPA, CDH, and the public for review. This plan specified activities to be conducted to complete the ER Program CRP, including plans for community interviews. The draft Community Relations Plan (CRP) was completed in September and the final CRP in November 1990, in accordance with the IAG schedules. Accordingly, a site-specific CRP is not required for OU 3. The ER Program community relations activities include participation by Plant representatives in informational workshops, meetings of the Rocky Flats Environmental Monitoring Council, briefings for the public on proposed remedial action plans, and meetings to solicit public comment on various ER Program plans and actions.

The RFP Communications Department is continuing other public information efforts to keep the public informed of ER activities and other issues related to Plant operations. A Speakers Bureau program sends speakers to civic groups and educational organizations, while a public tour program allows the public to visit Rocky Flats. An Outreach Program is also in place in which Plant officials visit elected officials, the news media, and business and civic organizations to further discuss issues related to Rocky Flats and ER activities. The Communications Department receives numerous public inquiries, which are answered through telephone conversations or by sending written informational materials to the requestor.

OU 3 activities to be performed as part of the ongoing community relations efforts include such activities or materials as preparation of briefings, fact sheets, and presentations, and participation in site tours or public meetings.

4.3 TASK 3—FIELD INVESTIGATION

A field investigation will be conducted at all of the OU 3 IHSSs to collect samples and data concerning the nature and extent of contamination at each unit. The data and sample results also will be used to support the Human Health Risk Assessment (Section 7.0 of this document), as well as meet the objectives and data needs described in Section 5.0 of this document. It is important to recognize that additional phases of investigation and risk assessment may be required at some

IHSSs, if contamination besides plutonium, and americium is detected, or if higher than anticipated concentrations of plutonium and americium are detected. A phased approach, if necessary, is consistent with the approach presented in EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a).

The following activities will be performed during the field investigation:

- Procurement of subcontractor (well driller and laboratories)
- Mobilization
- Well installation
- Media sampling
- Ecological surveys
- RI waste disposal.

The field investigation associated with IHSS 199 will deal primarily with soil and terrestrial biota sampling, while the field investigations associated with the reservoirs and drainages (IHSSs 200, 201, and 202) will focus on sediment, surface water, aquatic biota, and groundwater sampling. Details regarding the field investigation are provided in Section 6.0 of this document.

Detailed sampling plans will be developed for each sampling activity.

4.4 TASK 4—SAMPLE ANALYSIS AND DATA VALIDATION

A critical task in the RFI/RI is the sample analysis and data validation procedures. Data useability is critical in performing a quantitative risk assessment. The sample analysis and data validation procedures are essential elements of data useability. Activities included in this task are sample management, analyses, use of mobile laboratories, data validation, and testing of physical parameters.

The analytical methods will be completed in accordance with the ER Program Quality Assurance Project Plan (QAPP). Project-specific QA requirements are included in the QAA, Section 10.0 of this work plan. Section 6.0 of this document specifies the analytical requirements, and field QC requirements, as well as sample containers, preservation and holding times. The samples collected will be analyzed by an RFP contract laboratory.

Data will be reviewed and validated according to the data validation guidelines in the QAPP and the Date Validation Functional Guidelines (EG&G, 1990d). These documents state how the results of data review and validation activities will be conducted and documented in data validation reports.

4.5 TASK 5—DATA EVALUATION

The data evaluation task includes the analysis of data once it has been verified that the data are of acceptable accuracy and precision as described in Subsection 4.4 of this document. Activities associated with the data evaluation task include data evaluation, data reduction and tabulation, statistical analyses, and environmental fate and transport evaluation. The conceptual models will be refined based on new information as it is acquired.

Data collected during the field investigation will be incorporated into the existing data base, Rocky Flats Environmental Database System (RFEDS), and used to better define the nature and extent of contamination and to support the Baseline Risk Assessment. If the data collected supports historical data, the historical data will also be used to support the Baseline Risk Assessment.

4.6 TASK 6—BASELINE RISK ASSESSMENT

The purpose of this task is to conduct the Baseline Risk Assessment for OU 3. The purposes of the Baseline Risk Assessment is to assess the potential human health and environmental risks associated with the site and to provide a basis for determining whether remedial actions are necessary. The Baseline Risk Assessment includes a Human Health Risk Assessment and an Environmental Evaluation. The approaches to conducting these two assessments are presented in Sections 7.0 and 8.0 of this document. Conclusions from the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 Sites 200, 201, and 202 (DOE, 1991b) and the Final Past Remedy Report Operable Unit No. 3—IHSS 199 (DOE, 1991a), state that the specificity and quality of existing information are insufficient to perform a rigorous quantitative human health risk assessment. Additional data will be collected during the field investigations in order to perform a quantitative Baseline Risk Assessment. As previously stated, if the new data supports historical data, the historical data will also be used to support the Baseline Risk Assessment.

The sampling program is designed to generate data that meet the requirements of the Guidance for Data Useability in Risk Assessment (EPA, 1990b). Efforts included in this task are identification of contaminants of concern, characterization of animal and plant communities, exposure assessment, toxicity assessment, qualitative and quantitative uncertainty analysis, and risk characterization.

The Baseline Risk Assessment will address the potential public health risks and the environmental impacts. The current and potential (future) risks associated with the site under the no-action alternative (no remedial action taken) will be assessed based on the data collected. If the Baseline Risk Assessment determines that risks posed by contamination at OU 3 must be remediated, Tasks 7, 9, and 10 will be conducted. The Human Health Risk Assessment and Environmental Evaluation Work Plans are presented in Sections 7.0 and 8.0 of this document, respectively.

4.7 TASK 7—TREATABILITY STUDIES

The primary purposes of a treatability study is to provide sufficient technology performance information and to reduce cost and performance uncertainties to acceptable levels, so that treatment alternatives can be fully developed and evaluated during detailed analysis. The task includes efforts to evaluate whether treatability studies are necessary and, if so, to prepare for and conduct treatability studies. If remedial alternatives are developed, the data collected as part of the field investigation will be reviewed in terms of whether the alternatives can be evaluated. Based on the data collected and evaluated as part of the Preliminary Human Health Risk Assessment, it is unlikely treatability studies will be necessary. However, if additional data are required, treatability studies or field investigations will occur.

If it is determined that a treatability study is necessary, a treatability work plan will also be prepared. The plan will identify treatability tests that need to be conducted along with test materials and equipment needed.

The treatability work plan will discuss the following:

- The scale of the treatability test
- Key parameters to be varied and evaluated and criteria to be used to evaluate the tests
- Specifications for test samples and the means for obtaining these samples
- The test equipment, materials, and procedures to be used in the treatability test
- Identification of potential vendors who may conduct the tests and analytical services that will be conducted, as well as any special procedures and permits required to transport samples and residues and conduct tests
- The methods required for residue management and disposal
- Any special QA/QC needed for tests.

4.8 TASK 8—REMEDIAL INVESTIGATION REPORT

This task includes development of a draft and a final RFI/RI Report. The RFI/RI Report will summarize efforts related to the findings of the data evaluation and the Baseline Risk Assessment. Table 4-1 presents a typical outline for an RFI/RI Report. The RFI/RI Report will:

TABLE 4-1

SUGGESTED RI REPORT FORMAT

Executive Summary

1. Introduction
   - 1.1 Purpose of Report
   - 1.2 Site Background
     - 1.2.1 Site Description
     - 1.2.2 Site History
     - 1.2.3 Previous Investigations
   - 1.3 Report Organization

2. Study Area Investigation
   - 2.1 Includes field activities associated with site characterization. These may include physical and chemical monitoring of some, but not necessarily all, of the following:
     - 2.1.1 Surface Features (such as topographic mapping, natural and manmade features)
     - 2.1.2 Contaminant Source Investigations
     - 2.1.3 Surface Water and Sediment Investigations
     - 2.1.4 Soil Investigations
     - 2.1.5 Groundwater Investigations
     - 2.1.6 Human Population Surveys
     - 2.1.7 Ecological Investigations
   - 2.2. If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.

3. Physical Characteristics of the Study Area
   - 3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
     - 3.1.1 Surface Features
     - 3.1.2 Surface Water Hydrology
     - 3.1.3 Soils
     - 3.1.4 Hydrogeology
     - 3.1.5 Ecology

4. Nature and Extent of Contamination
   - 4.1 Presents the result of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the following media:
     - 4.1.1 Soils
     - 4.1.2 Groundwater
     - 4.1.3 Surface Water and Sediments
     - 4.1.4 Air

5. Contaminant Fate and Transport
   - 5.1 Potential Routes of Migration (such as air and groundwater)
   - 5.2 Contaminant Persistence
   - 5.3 Contaminant Migration

6. Baseline Risk Assessment
   - 6.1 Human Health Evaluation
     - 6.1.1 Exposure Assessment
     - 6.1.2 Toxicity Assessment
     - 6.1.3 Risk Characterization

TABLE 4-1

SUGGESTED RI REPORT FORMAT
(Concluded)

6.2 Environmental Evaluation

7. Summary and Conclusions
   7.1 Summary
      7.1.1 Nature and Extent of Contamination
      7.1.2 Fate and Transport
      7.1.3 Risk Assessment
   7.2 Conclusions
      7.2.1 Data Limitations and Recommendations for Future Work
      7.2.2 Recommended Remedial Action Objectives

Appendices
A. Technical Memoranda on Field Activities (if available)
B. Analytical Data and QA/QC Evaluation Results
C. Risk Assessment Methods

Source: EPA, 1988b

- Describe the field activities that serve as the basis for the RFI/RI Report in detail. This will include any deviations from the work plan that occurred during implementation of the field investigation.

- Discuss site physical conditions. This discussion will include surface features, meteorology, surface water hydrology, surficial and subsurface geology, groundwater hydrology, demography and land use, and ecology.

- Present site characterization results from RFI/RI activities at OU 3 to characterize the nature and extent of contamination, including contaminant sources, soils, sediments, groundwater, surface water, air, and biota.

- Discuss contaminant fate and transport. This discussion will include potential contaminant migration routes, contaminant persistence, and potential receptors.

- Present the Baseline Risk Assessment.

- Present a summary of the findings and conclusions.

- Identify data needs, if any.

4.9 TASK 9—REMEDIAL ALTERNATIVES DEVELOPMENT/SCREENING

This task includes efforts to develop and screen the remedial alternatives that will be subject to full evaluation. This task will be performed only if the Baseline Risk Assessment determines that the risks posed by contamination at OU 3 must be remediated. Activities to be included in the task, if performed, are the following:

- Establishing remedial action objectives

- Identifying and screening potential technologies
- Assembling potential alternatives
- Identifying location- and action-specific ARARs and refining chemical-specific ARARs
- Evaluating each alternative on the basis of screening criteria (effectiveness, implementability, and cost)
- Reviewing and providing Quality Assurance/Quality Control (QA/QC)
- Refining the list of alternatives to be evaluated.

4.10 TASK 10—DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to allow decisionmakers to select a site remedy. Each alternative retained after conducting Task 9 is assessed against the evaluation criteria and the results of the assessment are arrayed to compare the alternatives and identify the key trade offs. The following will be performed, if this task is needed:

- Refinement of alternatives
- Individual analysis of alternatives against the criteria
- Comparative analysis of alternatives against the criteria
- Review of QA/QC efforts
- Development of an FS.

Nine evaluation criteria have been established to address the statutory considerations and include the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

These criteria are described in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a). The initial two criteria are considered threshold criteria because these alternatives must be satisfied before further consideration of the remaining criteria. The next five criteria are considered the primary criteria on which the analysis is based. The final two criteria, state and community acceptance, will be addressed during the final decisionmaking process after completion of the CMS/FS.

As stated previously, the Baseline Risk Assessment will determine if any other risks posed by contamination at OU 3 require remediation.

5.0 DATA NEEDS AND DATA QUALITY OBJECTIVES

The primary objective of the RFI/RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants, and to quantify any risks to human health and the environment. Human health and environmental assessments help identify the need for remediation and are used along with the RFI/RI site characterization data to evaluate remedial alternatives, if necessary. The five general goals of an RFI/RI (EPA, 1988a) are to:

- Characterize the physical and biological nature of the site
- Define contaminant sources
- Determine the nature and extent of contamination
- Describe contaminant fate and transport
- Produce a baseline risk assessment (BRA) (human health and environmental risks).

DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA, 1987c). DQOs are developed using the following three-stage process:

- Stage 1–Identify decision types
- Stage 2–Identify data uses/needs
- Stage 3–Design a data collection program.

By applying the DQO process, site-specific RFI/RI goals were established and data needs were identified for achieving those goals. This section of the RFI/RI Work Plan presents the data needs and the DQOs for OU 3.

Data collected during previous investigations have been useful in defining and focusing the DQOs. However, previous data collection activities focused on site characterization and not on performing a quantitative human health risk assessment or an environmental evaluation. These historical data, along with the OU 3 conceptual model, are summarized in Section 2.0 of this work plan. This section presents the rationale used in identifying OU 3 data needs.

5.1 STAGE 1—IDENTIFY DECISION TYPES

Stage 1 of the DQO process identifies decisionmakers and data users, and defines the types of decisions that will be made as part of the RFI/RI. The general decision types are identified early in Stage 1 to determine data types sufficient to support decisions.

5.1.1 Identify and Involve Data Users

Data users are the decision makers, the primary, and secondary data users. The decisionmakers for OU 3 are the management and regulatory personnel of EG&G, the DOE, the EPA, the CDH, and the Rocky Flats Technical Review Group. EG&G's contractors will provide day-to-day management of the RFI/RI in accordance with this work plan. The decisionmakers have been and are involved in the OU 3 DQO process through the IAG, which specifies the minimum level of effort for the RFI/RI. The decisionmakers remain involved through the review and approval process specified in the IAG.

Primary data users are those individuals involved in ongoing RFI/RI activities. The primary data users are EG&G and EG&G's contractor. They will be involved in collecting and analyzing data and in preparing the RFI/RI Report, including the Human Health Risk Assessment and the Environmental Evaluation.

Secondary data users are those users that rely on RI outputs to support their activities. These users include EG&G and EG&G contractor personnel working on other OUs or sitewide projects, the DOE, the EPA, and the CDH.

5.1.2 Evaluate Available Data

Historical data for the IHSSs included in OU 3 have been reviewed and summarized in the Final Past Remedy Report Operable Unit No. 3–IHSS 199 (DOE, 1991a) and in the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 IHSS 200-202 (DOE, 1991b). Section 2.0 of this work plan summarizes previous work performed. The data useability of the previous data collected have been reviewed in accordance with the Guidance for Data Useability in Risk Assessment (EPA, 1990b) procedures. The conclusions of the review indicate that much of the data does not meet the necessary DQOs to perform a rigorous quantitative BRA (human health and environmental).

5.1.3 Develop Conceptual Model

The OU 3 conceptual model is presented in Subsection 2.5. The model includes a description of potential sources, pathways, and receptors. The potential pathways identified are those associated with soil, surface water, groundwater, aquatic and terrestrial biota, and air/wind. The potential release mechanisms include fugitive dust and wind erosion, surface runoff, infiltration and percolation, biotic uptake, and tracking by organisms. The primary pathway is through the air/wind dispersion of surface soils. This pathway, and the other potential pathways, will be characterized and evaluated during the RFI/RI for this OU.

5.1.4 Specify RFI/RI Objectives and Data Needs

Based on existing data and the conceptual model presented in Section 2.0, the site-specific RFI/RI objectives and data needs associated with determining the nature and extent of contamination and performing the Human Health Risk Assessment and Environmental Evaluation were developed.

The objectives of the RFI/RI are to:

- Characterize site physical features and ecological characteristics of the site

- Characterize the nature and extent of contamination at each IHSS in each media that is a potential pathway

- Collect data to support the quantitative Human Health Risk Assessment

- Collect data to support the Environmental Evaluation.

5.2 STAGE 2—IDENTIFYING DATA USES/NEEDS

Stage 2 of the DQO process defines data uses and specifies the data types needed to meet the project objectives. The conceptual model presented in Section 2.0 of this work plan was the basis for identifying data needs. For an exposure pathway to be complete, there must be a contaminant source, release mechanism, transport mechanism, route of exposure, and a receptor. To evaluate each potential exposure pathway identified in the conceptual model, the historical data and some of the ongoing RFP site environmental monitoring data was reviewed to determine if information of sufficient quality and quantity was available to characterize the OU and to perform the quantitative Human Health Risk Assessment and the Environmental Evaluation.

The data review indicated that the existing data were not of sufficient quality to meet the DQOs for performing a quantitative BRA. The data needs identified for this RFI/RI focus on confirming past sampling results. If past sampling results are confirmed, historical data will be used to substantiate the quantitative BRA.

Characterizing each potential exposure pathway is considered a data need for this OU. Because most of the data needs have multiple data uses, the characterization data will be used for site characterization and for performing the Human Health Risk Assessment and the Environmental Evaluation.

Table 5-1 describes the data needed to fulfill specific objectives, including the pathway addressed; the type of activity required to collect the data; the analytical level; and the intended data use. Each data need and field activity is designated by a data item number(s). The data item numbers are referenced in the FSP (Sections 6.0 and 8.0). In addition, the pathways addressed by each data need are numbered. The numbered pathways are depicted in Figures 2-14 and 2-16 and Appendix A.

The following subsections describe the Stage 2 DQO steps that were followed to develop Table 5-1.

5.2.1 Identifying Data Uses

Data uses for OU 3 include the following:

- Site characterization
- Human Health Risk Assessment
- Environmental Evaluation
- Community Relations.

5.2.2 Identifying Data Types

Data types can be initially specified in broad groups and then divided into more specific components. For example, soil, sediment, groundwater, surface water, air, terrestrial, and biota samples will be collected during the field investigation. The selection of analytical parameters and physical testing was based on the OU 3 RFI/RI objectives and on past activities. These data types provide information to evaluate potential pathways identified in the conceptual model and meet the other objectives of the RFI/RI presented in Subsection 5.1.4.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
CHARACTERIZE NATURE AND EXTENT OF SURFACE WATER AND SEDIMENT CONTAMINATION					
SW-1, SW-2	Characterize potential plutonium, americium, uranium, metals, and volatile contamination (Mower Reservoir only) in surface water reservoirs and drainages/ditches	Collect water samples from each reservoir and several drainages/ditches with surface flow at time of sampling. Samples will be analyzed for plutonium, americium, uranium, gross alpha, gross beta, atrazine, simazine, Target Analyte List (TAL) metals, and cation/anions. Target Compound List (TCL) volatiles will be analyzed at Mower Reservoir, since it has not been analyzed for volatiles. Trtium will also be anlayzed in surface water stations located along Indiana Street.	II–Dissolved oxygen, pH, temperature, and electrical conductivity III–Cation/anions IV–TAL metals and TCL volatiles V–Radionuclides V–Herbicides	• Site characterization • Risk assessment–assess pathway and potential exposure through ingestion of surface water • Environmental evaluation	4,9,12
SED-1, SED-2	Characterize potential contamination in drainage/ditches and reservoir sediments	Collect sediment samples from reservoirs and drainages/ditches and analyze for plutonium, americium, uranium, gross alpha, gross beta, and TAL metals. TCL volatiles will only be analyzed in Mower Reservoir and its drainage, since they have not been analyzed for volatiles. Tritium will only be analyzed along Walnut Creek since there was a release.	IV–TCL VOAs, TAL metals, V–Radionuclides	• Site characterization • Risk assessment–assess transport media • Environmental evaluation	3,7,8,10

[1] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
SED-3	Characterize potential plutonium, americium, and uranium entrapment to sediments exposed along reservoir shoreline	Collect sediment samples along reservoir shoreline and analyze for plutonium, americium, uranium, and TAL metals. TCL volatiles will only be analyzed in Mower Reservoir.	IV–TCL VOAs, TAL metals V–Radionuclides	• Site characterization • Risk assessment • Environmental evaluation	3,7,8,10,14
CHARACTERIZE NATURE AND EXTENT OF SOIL CONTAMINATION					
S-1	Characterize vertical extent of soil contamination	Collect undisturbed soil samples from vertical profile to a depth of approximately 100 cm and analyze for plutonium, americium, and uranium.	V–Radionuclides	• Site characterization • Risk assessment–assess pathway and transport potential • Environmental evaluation	1,2,5
S-2	Characterize lateral extent of soil contamination	Collect surface soil samples using CDH method and analyze samples for plutonium, americium, and uranium. A sampling grid based on geostatistics will be used.	V–Radionuclides	• Site characterization (current source) • Risk assessment–assess pathway and potential exposure through ingestion of soils • Environmental evaluation	1,2,3,4,6
S-3	Delineate lateral extent of soil types and correlate with vegetation types	Identify soil types.	I–Field observation	• Environmental evaluation	6

[1]Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
S-4	Characterize fate and transport of plutonium and americium	Soil and sediment samples will be collected and analyzed for particle size, bulk density, and total organic carbon content. Results of the physicochemical processes of plutonium that is being performed for OU 2 will be reviewed.	III—Particle size, bulk density, total organic carbon (TOC)	• Risk assessment—assess transport potential	1,2,3,4,6
CHARACTERIZE HYDROGEOLOGY					
GW-1	Characterize hydrogeology near IHSSs and groundwater/surface water contamination and interactions	Install monitoring wells in alluvium and bedrock and collect groundwater samples and analyze for plutonium, americium, uranium, gross alpha, gross beta, and cation/anions. Water level measurements will also be collected.	I—Field parameters III—Cation/anions V—Radionuclides	• Site characterization • Risk assessment—assess pathway and potential exposure through ingestion of ground water • Environmental evaluation	5,10,12

[1]Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
CHARACTERIZE AIR PATHWAY					
A-1	Characterize particulates in air	Collect discrete air samples from exposed reservoir sediments and vegetated soil area using a wind tunnel and analyze air samples for plutonium, americium, and uranium. Two continuous air samplers will also be installed near Standley Lake. Existing RAAMP samplers located in the community will be used for background data evaluations.	V—Radionuclides	• Site characterization • Risk assessment—assess pathway, transport media, and potential exposure through inhalation	1,7,14
CHARACTERIZE ECOLOGICAL SETTING					
Characterize Terrestrial Biota					
B-1	Characterize vegetation types	Conduct field reconnaissance for species and cover using quadrant sampling	I—Field surveys	• Site characterization • Comparative ecology	6,11
B-2	Characterize animal species and populations	Conduct field surveys for major species of mammals, birds, and reptiles	I—Field surveys	• Site characterization • Comparative ecology	6,11
B-3	Characterize wetlands/riparian zones	Conduct qualitative survey for types, size, location, and major species	I—Field surveys	• Site characterization • Comparative ecology	6,11

[1]Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
B-4	Assess bioaccumulation in vegetation	Analyze tissue samples from above-ground plant biomass for plutonium, americium, and uranium	V--Radionuclides	• Toxicity assessment • Exposure pathways	6,11
B-5	Assess bioaccumulation and concentration in wetland vegetation	Analyze tissue samples for plutonium, americium, uranium, and TAL metals	V--TAL metals, radionuclides	• Toxicity assessment • Exposure pathways	6,11
B-6	Assess bioaccumulation in small mammals	Analyze tissue samples for plutonium, americium, and uranium	V--Radionuclides	• Toxicity assessment • Exposure pathways	6,11
Characterize Aquatic Biota					
AQ-1	Characterize benthic macroinvertebrate communities in creeks and reservoirs	Collect qualitative samples. Identify dominant taxa and enumerate. Identify trophic types and spatial distribution.	I--Field Surveys V--Biological analyses	• Site characterization • Exposure pathways • Ecological endpoints • Comparative ecology	13
AQ-2	Characterize periphyton in creeks and reservoir areas	Collect qualitative samples from natural substrates. Record major types, relative abundance.	I--Field Data V--Biological analyses	• Site Characterization • Comparative ecology	13

[1]Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO. 3
(Concluded)

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed[1]
AQ-3	Characterize fish communities in creeks and reservoirs	Collect fish with seines and dip nets. Identify, enumerate, and measure common species. Determine relative abundance and trophic types.	I—Field Data V—Biological analyses	• Site characterization • Exposure pathways • Ecological endpoints • Comparative ecology	13
AQ-4	Measure ecological endpoints in benthic macroinvertebrate communities. Assess bioaccumulation.	Collect replicate grab samples and dip net or kick net samples. Analyze ecological endpoints. Measure bioaccumulation in tissue.	I—Field data V—Biological analyses V—Radionuclides and TAL metals	• Exposure pathways • Toxicity assessment • Ecological endpoints • Bioaccumulation	13
AQ-5	Characterize periphyton communities and determine colonization rates	Collect periphyton on artificial substrates in reservoirs. Identify major types and determine relative abundance. Measure biomass.	I—Field Data V—Biological analyses	• Exposure pathways • Comparative ecology	13
AQ-6	Measure ecological endpoints in fish communities. Assess bioaccumulation and toxicity of contaminants.	Collect fish with electroshocker and gill nets. Identify, count, measure, and weigh. Analyze ecological endpoints. Measure bioaccumulation in tissue. Test water/ sediments for toxicity.	I—Field data V—Biological analyses V—Radionuclides and TAL metals	• Exposure pathway • Toxicity assessment • Ecological endpoints • Bioaccumulation	13

[1]Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

5.2.3 Identifying Data Quality Needs

The EPA defines five levels of analytical data (EPA, 1987c) associated with data quality. The analytical levels correspond with those noted in Table 5-1.

- **Level I**—Field screening or analysis using portable instruments. Results are often not compound specific or quantitative, but results are available in real-time. Level I is the least costly analytical option. Level I is typically used for initial site characterization.

- **Level II**—Field analyses using more sophisticated portable analytical instruments. In some cases, the instruments may be set up in a mobile laboratory onsite. There is a wide range in the quality of data that can be generated. Quality depends on using suitable calibration standards, reference materials, and sample preparation procedures; and training the operator. Results are available in real time or several hours later. Level II is typically used for site characterization and evaluation of alternatives.

- **Level III**—These analyses are performed in an offsite analytical laboratory. Level III analyses may or may not use contract laboratory program (CLP) procedures, but do not usually use the validation or documentation procedures required of CLP Level IV analysis. The laboratory may or may not be a CLP laboratory. Level III is typically used for site characterization, evaluation of alternatives, and risk assessment.

- **Level IV**—CLP routine analytical services (RAS). All analyses are performed in an offsite CLP analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and documentation. Level IV is typically used for risk assessment and evaluation of alternatives.

- **Level V**–Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP special analytical services (SAS) are Level V. Level V is typically used for risk assessments.

The levels appropriate to the data need and the data use have been specified on Table 5-1. The levels, as they apply to this work plan and specific activities, are presented in Table 5-2, and have been identified by comparing the detection limits for an analytical method to the preliminary OU 3 chemical-specific ARARs.

5.2.4 Identifying Data Quantity Needs

Data quantity needs were based on a review of the historical data presented in the Final Past Remedy Report (DOE, May 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment (DOE, May 1991b). Some data collected previously at the site helped focus the additional data quantity needs. In addition, the EPA's Guidance for Data Useability in Risk Assessments (EPA, 1990b) has been followed to help determine the data quantity needs.

The rationale for sampling quantities is described Section 6.0–Field Sampling Plan. In areas where some data exist (such as soil samples), a statistical approach to defining sample quantity and location was followed. The rationale for sample quantities also assumed that the data to be collected will confirm past results, and that some of the historical data will be used qualitatively to support the Human Health Risk Assessment and the Environmental Evaluation.

5.2.5 Evaluating Sampling/Analysis Options

Data collection activities must be designed to obtain maximum use of the data. The sampling/ analysis approach for this work plan is based on previous site investigations. If sampling does not confirm previous investigations, additional data collection activities may be necessary. However, an

TABLE 5-2

LEVEL OF ANALYSIS
OPERABLE UNIT NO. 3

Required Analytical Level	Task
Level I (Field Screens)	• Water level measurement • pH measurement (field) • Temperature (field) • Specific conductance (field)
Level II (Field Analyses)	• Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	• Major ion analysis • Organics analysis • Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	• Analysis of Target Compound List (TCL) and Target Analyte List (TAL)
Level V (Nonstandard Analyses)	• Radiological analyses • Contaminant analyses requiring modification of standard methods • Special Analytical Services (SAS) • Bioaccumulation in biota (TAL metals) • Biological analyses

Source: U.S. EPA (1987c)

effort has been made to anticipate most of the field work necessary to meet the DQOs. In addition, results from other OUs and from the OU 3 sampling program will be evaluated as data become available. If results indicate that additional analyses or sampling is necessary, modifications will be made to the sampling program. This will be done to avoid performing a successive RFI/RI.

5.2.6 Review of PARCC Parameter Information

Precision, accuracy, representativeness, completeness and comparability (PARCC) parameters are indicators of data quality. Precision, accuracy, and completeness goals were established for this work plan based on the analyses to be performed and the analytical levels. In the quantitative Human Health Risk Assessment and the Environmental Evaluation, only data that have been reviewed and have met specific criteria can be used. A summary of the minimum requirements for data quality indicators is presented in Table 5-3, as is a description of the potential impact to the Human Health Risk Assessment and the suggested corrective action. The criteria presented in Table 5-3 will be used to evaluate the data useability of the data collected from the OU 3 field sampling program.

The analytical program requirements for OU 3 are discussed in Subsection 6.3 of this work plan. The analytical program specifies the use of analytical methods referenced in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (DOE, 1990c) for all analytes. These analytical methods are appropriate for meeting the data quality requirements for analytical levels II through V. The precision, accuracy, and completeness parameters for analytical levels II through V are discussed below along with the comparability and representativeness for all analytical levels. The DQOs specified for the precision, accuracy, and completeness will be used in evaluating the quality and useability of the laboratory and field data.

Precision and accuracy objectives for the analytical data collected for OU 3 will be evaluated based on the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP will be

TABLE 5-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO. 3

Data Useability Criterion	Minimum Data Quality Requirement	Potential Impact on Risk Assessment	Suggested Corrective Action
Reports to Risk Assessor	• Site description • Sample design with sample locations • Analytical method and detection limit • Results on per-sample basis, qualified for analytical limitations • Sample-specific quantitation limits (SQLs) and detection limit for nondetects • Field conditions for media and environment • Preliminary reports	• Unable to perform quantitative risk assessment	• Request missing information • Perform qualitative risk assessment
Documentation	• Sample results related to geographic location (chain-of-custody records, SOPs, field and analytical records)	• Unable to assess exposure pathways • Unable to identify appropriate concentration for exposure areas	• Request locations identified • Resampling

TABLE 5-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO. 3 (Continued)

Data Useability Criterion	Minimum Data Quality Requirement	Potential Impact on Risk Assessment	Suggested Corrective Action
Data Sources	• Analytical data results for one sample per medium per exposure pathway • Broad spectrum analysis for one sample per medium per exposure pathway • Field measurements data for media and environment	• Potential for false negatives and positives • Increased variability in exposure modeling	• Resampling or reanalysis for critical samples
Analytical Method and Detection Limit	• Routine methods used for critical samples and chemicals of potential concern • Detection limit less than 20 percent of concentration of concern	• Unquantified precision and accuracy • False negatives	• Reanalysis • Resampling and analysis for critical samples • Documented statements of limitation for noncritical samples

TABLE 5-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO. 3 (Continued)

Data Useability Criterion	Minimum Data Quality Requirement	Potential Impact on Risk Assessment	Suggested Corrective Action
Data Review	• Correctness of analytical results reviewed	• Potential for false negatives or false positives • Increased variability and bias because of analytical process, calculation, or transcription errors	• Perform data review
Data Quality Indicators	• Sampling variability quantified for each analyte • QC samples required to identify and quantify precision and accuracy • Sampling and analytical precision and accuracy quantified	• Unable to quantify confidence levels for uncertainty • Potential for false negatives or false positives	• Resampling for critical samples • Perform qualitative risk assessment • Perform quantitative risk assessment for noncritical samples with documented discussion of potential limitations

Source: Guidance for Data Useability In Risk Assessment (EPA, 1990b).

followed. The specified criteria for precision and accuracy are described in Section 10.0–Quality Assurance Addendum for OU 3.

The target completeness objective for the OU 3 field and analytical data is 90 percent.

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared with another. In order to achieve comparability, work performed at OU 3 will follow approved sampling and analysis plans, use standardized analytical protocols, collect data following Standard Operating Procedures (SOPs), and report data in consistent units of measurement.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that is most concerned with the proper design of the sampling program. The FSP described in Section 6.0 of this work plan, as well as the referenced SOPs, describe the rationale for the sample program to provide for representative samples. In designing the field sampling program, statistical considerations were given in selection of sample locations and sample numbers.

5.3 STAGE 3–DESIGN DATA COLLECTION PROGRAM

The purpose of Stage 3 of the DQO process is to design the specific data program for the OU 3 RFI/RI. To accomplish this, the elements identified in Stages 1 and 2 were assembled and the FSP was prepared. The FSP and the Quality Assurance Addendum are presented in Sections 6.0 and 10.0 of this work plan, respectively. A detailed discussion of all samples to be obtained is presented in Subsection 6.4 for each media and includes sample type, number of samples, sample location, analytical methods, and QA/QC samples.

6.0 FIELD SAMPLING PLAN

6.1 INTRODUCTION

The purpose of this section of the work plan is to present the FSP that has been developed to meet the RFI/RI objectives. As stated in Section 5.0, the primary objectives of the RFI/RI are to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants; and to quantify any risks to human health and the environment. More specific objectives were listed in Subsection 5.1.4. Based on these objectives, the site-specific DQOs and data needs have been identified in Section 5.0, and are the basis for developing the field sampling plan in this section. Field sampling activities, by media, are presented in Subsections 6.3.2 through 6.3.6. The field sampling plan for the environmental evaluation is presented in Section 8.0.

The FSP presents a summary of previous OU 3 activities, a discussion of relevant studies by other OUs, rationale for chemical analyses, and field sampling activities by media--soil, sediments, surface water, groundwater, and air. Following the description of sampling activities, the sample analysis program (sample designations, analytical requirements, sample containers and preservations, sample labeling and documentation, and data reporting requirements) and the field quality control procedures are discussed. As discussed in Subsection 4.3, detailed sampling plans will be developed before performing the specific sampling activities.

6.1.1 Background

Previous investigations in the vicinity of OU 3 have been performed and are described in the Past Remedy Report (DOE, 1991a), the Historical Information Summary and Preliminary Health Risk Assessment (DOE, 1991b), and briefly in Section 2.0 of this work plan. These data have helped focus the field activities necessary to complete the RFI/RI and perform the quantitative Human

Health Risk Assessment and Environmental Evaluation. Additional field investigations are being performed for other OUs and in the environmental monitoring program performed by EG&G, CDH, and the cities of Broomfield, Westminster, Thornton, and Northglenn as mentioned previously in Subsections 1.3.8 and 1.3.9. Some of these studies are discussed in more detail in Subsection 6.1.2. In order to not duplicate ongoing work at Rocky Flats, these investigations have been reviewed to help focus OU 3 data needs and to identify which data will be evaluated with the OU 3 data.

An evaluation of data useability for existing data at IHSS 199 through 202 was performed and summarized in the Final Past Remedy Report (DOE, May 1991a) and the Historical Information Summary and Preliminary Health Assessment (DOE, May 1991b). The evaluation concluded that few of the criteria found in the EPA Guidance Document for Data Useability in Risk Assessment (EPA, 1990b) were met. The FSP developed in this work plan is designed with the intent of the data collected to meet the criteria described in the EPA guidance. The FSP is also designed to evaluate results of previous investigations. If the historical results are confirmed, previously collected data will be used to substantiate the quantitative Human Health Risk Assessment and the Environmental Evaluation. If the previous sampling results are not confirmed and contaminants other than plutonium and americium are detected, another phase of field sampling may be required.

The Guidance for Data Useability In Risk Assessment (EPA, 1990b) provides guidance for evaluating the necessity of alternative sampling strategies and designing a statistical sampling plan. The objective is to determine a strategy that collects data representative of conditions at the site and is within resource limitations. The rationale for each sampling program is provided in Subsection 6.3.

6.1.2 Relevant Studies of Other OUs

As previously mentioned, investigations are occurring at OU 2–903 Pad, Mound, and East Trenches Areas; OU 4–207 Solar Evaporation Ponds; OU 5–Woman Creek, and OU 6–Walnut Creek Priority Drainage that are relevant to OU 3. Similar field sampling techniques and analytical methods will be used, where appropriate, so data collected from the OUs are comparable. Work performed in other

OUs will also be used when evaluating OU 3 results. In addition, some of the sampling results from OUs 2 will be available before OU 3 sampling begins. The OU 2 results that are available will be reviewed and modifications to the OU 3 sampling program will be made, if necessary. As other OU data are available, they will be incorporated into OU 3 evaluations.

At OU 2, studies to evaluate the static and mobile soil phase of the physicochemical association of plutonium and americium will be performed. This work will provide information on the mobility and environmental fate of radionuclides in the soils. Hydrological analyses of the frequency, duration, and intensity of summer precipitation events and spring snowmelt events, coupled with direct measurements of solute transport in soils, will provide information to assess the movements of water and radionuclides (dissolved and particulate) down through the soil column. A description of the work to be performed is provided in Attachment 1 of the Final Phase II RCRA Facility Investigation Remedial Investigation Work Plan for OU 2 (EG&G, 1991a). The information provided from these studies at OU 2 will be applied to predict the fate and transport of plutonium and americium found in soils and sediments at OU 3.

At OU 4, the solar evaporation ponds, some of the surface soils in the vicinity of Ponds 207A, 207B, 207C and surrounding the RCRA Waste Management Area will be sampled and analyzed for TAL metals as well as radionuclides. These surface soil metal analyses will help characterize potential sources of metals from the solar evaporation ponds. If this area is confirmed as a source of metals likely to be dispersed through the air pathway across RFP boundaries, metals will be investigated in soils at OU 3. However, since a sufficiently large source of metals contamination that could be transported via the air pathway has not been identified, metals will not be investigated in OU 3 soil samples at this time. Additional discussions regarding the soil sampling program for OU 3 is presented in Section 6.2.2.4.

At OUs 5 and 6, the Woman Creek and Walnut Creek drainages are being investigated. The results from these activities will be used in evaluating the drainage investigations for OU 3. In addition, background sampling for OU 6 will consist of sediment and surface water sampling that will be collected west of OU 6 to provide background information on Walnut Creek. This information will be used in evaluating sediment and surface water results from the OU 3 investigation. Background groundwater quality will be based on the 50 wells that were installed in 1989 as part of the network to characterize upgradient groundwater unaffected by RFP (Rocky Flats Plant Site Environmental Report, January through December 1989) (EG&G, 1990b). The wells are sampled quarterly as part of the Rocky Flats Plant site environmental monitoring program. In addition, the Background Geochemical Characterization Report for 1989 (EG&G, 1990f), describes and summarizes background geochemical data for the RFP.

If results from any of the work being performed on the RFP site indicate other contaminants likely to be dispersed through the air pathway across RFP boundaries, the OU 3 FSP will be reevaluated. This reevaluation will include involving the EPA, CDH, DOE, and EG&G and subcontractor personnel to identify appropriate changes to the OU 3 FSP.

6.1.3 Summary of Field Investigation Activities

In Section 5.0, general data needs were identified with their associated data quality objectives. A detailed sampling program for OU 3 was developed from these data needs and data quality objectives. A summary of field sampling activities by media for OU 3 is presented in Table 6-1. The table summarizes the purpose of the field activity, location, estimated number of sample locations, and the rationale for the activity. The first column includes data need designations and the last column indicates the pathways from the conceptual models that are being addressed. The designations can be used to cross-reference the proposed sampling activity to Table 5-1, which identifies the OU 3 data needs. The following subsections provide additional detail by media: soil, sediment, surface water, groundwater, and air and describe the rationale for chemical analyses and the field sampling procedures to perform field activities.

6.2 OU 3 CHEMICAL ANALYSES RATIONALE

This subsection presents the rationale for selecting OU 3 specific chemical analyses. The identification and rationale for OU 3 chemical analyses selection has followed EPA guidance

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OPERABLE UNIT NO. 3

Data Need Addressed/ Field Activity[1]	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed[3]
SOIL						
S-1, S-4 Profile soil sampling	Characterize vertical plutonium americium, and uranium concentrations in undisturbed areas	• Plutonium, americium, and uranium • Ten percent of the samples will also be analyzed for total organic carbon (TOC), bulk density, and grain size	Undisturbed areas identified from historical aerial photographs. Samples will be collected using the modified trench method. Samples will be collected to a depth of approximately 100 cm.	Undisturbed areas identified from aerial photographs (11 locations).	Undisturbed areas have the highest potential for accumulation of contaminants. The locations were identified from the aerial photograph review and field reconnaissance.	1,2,5
S-2, S-4 Soil grid survey	Delineate lateral extent of plutonium, americium, and uranium contamination and verify/ confirm previous soil sampling.	• Plutonium, americium, and uranium • Ten percent of samples will be analyzed for bulk density, grain size, and TOC	1,000 meter grid spacing east of Indiana Street	Approximately sixty 10-acre plots will be sampled.	Sampling grid based on geostatistical kriging of previous soil data.	1,2,3,4,6
S-3 Soil types	Delineate lateral extent of soil types and correlate with vegetation types	Standard soil survey analyses	Undisturbed or minimally disturbed areas	As needed to correspond to vegetation sampling.	Field reconnaissance and survey will be sufficient to determine if soil types are supporting unexpected vegetation or vegetation typical for the habitat.	6

Notes: [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations may be refined based on field decisions. Quality control samples are not included.
[3] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed/ Field Activity[1]	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed[3]
SEDIMENT						
SED-1, S-4 Sediment sampling in drainages/ditches	Characterize contamination in drainages/ditches	• Plutonium, americium, uranium, and gross alpha and beta • TCL volatiles along Mower Ditch only • TAL metals • Ten percent of the samples will be analyzed for TOC, bulk density, and grain size • Tritium will be analyzed in sediment samples along Walnut Creek	Sediment samples will be collected in Walnut Creek, Broomfield Diversion Ditch, Woman Creek, and ditch above Mower Reservoir.	• 7–Above and below Great Western Reservoir along Walnut Creek drainages • 2–Broomfield Diversion Ditch • 5–Above and below Mower Reservoir • 7–Above Standley Lake along Woman Creek drainages • 2–Church Ditch • 1–Near the inlet of Clear Creek Irrigation Ditch • 2-Unnamed drainages • 2-Smart Ditch • 1-Big Dry Creek	Drainages/ditches are a potential pathway for offsite migration.	3,7,8

Notes: [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations may be refined based on field decisions. Quality control samples are not included.
[3] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed/ Field Activity[1]	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed[3]
SED-2, S-4 Sediment sampling in reservoirs	Characterize sediments in reservoirs. Vertical profile sample of sediments from reservoirs will provide information on plutonium, americium, and uranium concentrations as it varies with depth. *Grab samples will be collected to* characterize potential metals and volatile contamination (Mower Reservoir only).	• Plutonium, americium, and uranium for vertical profile samples • Ten percent of the samples will be analyzed for TOC, bulk density, and grain size • TAL metals, plutonium, americium, *uranium, gross alpha and beta on* grab samples, and TCL volatiles for Mower Reservoir only	Sediment samples will be located near where samples from the 1983 and 1984 sampling occurred. Vertical profile samples (for radionuclides) and a grab sample (for VOAs in Mower Reservoir and *metals) will be collected.*	• 15 grab, 3 vertical profile–Great Western Reservoir • 5 grab, 3 vertical profile–Mower Reservoir • 18 grab, 4 vertical profile–Standley Lake	The vertical profiling of radionuclides will help identify depths of plutonium, americium, and uranium contamination. Grab samples will be analyzed for the TCL VOAs *in* Mower Reservoir, and TAL metals to identify presence of other potential contaminants. Grab sample locations will correspond to historical locations.	3,8,10
SED-3, S-4 Near-shore sediment sampling of reservoirs	Characterize sediments that may be potentially exposed during low reservoir capacity. In addition, one sample per reservoir will be a vertical profile sample to characterize how plutonium, americium, and uranium, vary with depth.	• Plutonium, americium, uranium, and gross alpha and beta • TCL volatiles for Mower Reservoir • TAL metals • Ten percent of the samples will be analyzed for TOC, bulk density, and grain size	Samples will be collected in exposed sediments around each reservoir.	• 15–Around Great Western Reservoir, 1 vertical profile • 15–Around Standley Lake, 1 vertical profile • 5-Around Mower Reservoir, 1 vertical profile	Exposed sediments are a potential pathway of dispersion of contaminants by wind.	3,7,8,10,14

Notes: [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations may be refined based on field decisions. Quality control samples are not included.
[3] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed/ Field Activity[1]	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed[3]
SURFACE WATER						
SW-1 Sample surface water drainages/ditches	Characterize plutonium, americium, uranium, and metals in surface water drainages. Drainages flow intermittently. Will use current sampling stations at Walnut and Women Creek along Indiana Street and supplement with several other locations.	• Plutonium, americium, uranium, and gross alpha and beta • TAL metals • Atrazine and simazine • Cations/anions • DO, pH, EC, temperature	• Drainages along Indiana Street that are already part of onsite monitoring program. Several other drainages/ditches will be sampled, if flowing, for site characterization.	• 1–Smart Ditch • 2–Church Ditch • 1–Broomfield Diversion Ditch • 1–Woman Creek • 1–Walnut Creek • 1–Big Dry Creek • 1–Clear Creek Irrigation Ditch	Sample stations along Indiana Street are located closest to potential sources. The Woman Creek, Big Dry Creek, and Walnut Creek locations will be used in the aquatic evaluation and the Church Ditch, Smart Ditch, and Clear Creek Irrigation Ditch samples will be used for site characterization.	4,9,12
SW-2 Sample Reservoirs	Characterize radionuclides, VOAs in Mower Reservoir, and metals in surface water and variations in plutonium americium, and uranium in vertical profiles	• Plutonium, americium, uranium, and gross alpha and beta • TAL metals • TCL volatiles in Mower Reservoir only • Atrazine and simazine • Cations/anions	Deepest area of each reservoir and in bays of reservoir	• 5–Great Western • 5–Mower • 5–Standley Lake	Supplements and verifies existing data. Two surface water sampling events are scheduled, one during high flow and one during low flow. Composite samples will be collected from various depths in the water column.	4,9,12

Notes: [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations may be refined based on field decisions. Quality control samples are not included.
[3] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Concluded)

Data Need Addressed/ Field Activity[1]	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed[3]
GROUNDWATER						
GW-1 Install and sample groundwater monitoring wells	To obtain site-specific hydrogeology and assess plutonium, americium, and uranium in alluvial and confined groundwater systems	• Plutonium, americium, uranium, and gross alpha and beta • Cations/anions	Downgradient of Great Western Reservoir and Standley Lake	• 2–Great Western Reservoir • 2–Standley Lake	Provides data to evaluate if contaminants in sediments or surface water have migrated to groundwater from the reservoirs. Provides site-specific information on hydrogeology. Wells will be sampled quarterly for 1 year.	5,10,12
AIR						
A-1 Discrete air sampling	Characterize the potential for dispersion of plutonium americium, and uranium contaminated sediments and soils. Existing RAAMP samplers located in the community will be used for background data evaluations.	• Plutonium, americium, and uranium	Discrete sampling using wind tunnel in low lying areas where reservoir sediments are exposed and in a vegetated area. Discrete sampling using ultra high-volume air sampler at two locations near Standley Lake.	• 1–Location at Great Western • 1–Location at Standley Lake • 1–Vegetated area • 2–Ultra hi-volume air samplers near Standley Lake	Exposed sediments are most likely to be entrapped and resuspended into the air. Using a wind tunnel will identify wind speeds where resuspension occurs.	1,7,14

Notes: [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations may be refined based on field decisions. Quality control samples are not included.
[3] Conceptual model pathway designations as presented in Figures 2-14, 2-16, and Appendix A.

documents including Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988), Data Quality Objectives for Remedial Response Activities (EPA, 1989), and Guidance Document for Data Useability in Risk Assessment (EPA, 1990b).

For the identification of OU 3 specific data analyses, data from the comprehensive site characterization that has been ongoing at OU 1 and 2 since 1986 were reviewed. In addition, annual monitoring by EG&G, CDH, and the cities of Broomfield, Westminster, Thornton, and Northglenn have been performed on and around the RFP as part of the site environmental monitoring. The data review has focused on data from groundwater, surface water, and sediments along Indiana Street, just west of OU 3. These locations represent the downgradient property boundary of the RFP. If contaminants are not detected in these locations, they are not likely to be present in OU 3. This approach, in conjunction with the conceptual pathway models that identify sources and release mechanisms, has been used to select the analytical program for OU 3.

6.2.1 Approach

The approach to identifying and selecting the chemical analyses for OU 3 consists of the following two steps:

- **Step 1**–Summarize compounds that have been detected along Indiana Street for groundwater, surface water, and sediments by analytical group

- **Step 2**–Evaluate results to identify prevalent compounds and contaminants of concern.

In Step 1, pertinent data are tabulated showing the number of detections of each chemical that are detected one or more times, the maximum value detected and the average of the detected values.

Compounds that were not detected are not included in the summaries. This is performed for each media sampled. The analytical groups are as follows:

- TCL volatile organic analyses (VOAs)
- TCL Semivolatiles
    - Acid Extractables
    - Base/Neutral Extractables
- Pesticides/PCBs
- Radionuclides
- Target analyte list (TAL) metals.

Three possible outcomes are identified through the tabulation of data:

- **Case 1**–The tabulation demonstrates that chemicals within one or more analytical groups in a specified media have not been detected at the given detection limit. Therefore, additional sampling for that analytical group is not necessary to achieve the RFI/RI objectives.

- **Case 2**–The tabulation demonstrates that one or more chemicals from an analytical group have been detected in a specified media either inconsistently or at low concentrations and further evaluation should be made as to whether additional investigative sampling and analysis is necessary. Evaluations include toxicity and mobility of compounds, and historical releases of compounds known to have occurred onsite.

- **Case 3**–The tabulation demonstrates consistent detections of one or more chemicals from an analytical group in a specified media and suggests that further investigative sampling and analysis is required to achieve the RFI/RI objectives.

After tabulating the results and assigning either Case 1, 2, or 3 to the chemical groups, the implications of eliminating the analytical group from the sampling program were evaluated. In Case 1, the analytical group can be eliminated provided the historical data are of adequate quality or useability, and are representative of the site. Data quality is assessed in accordance with the QAPP, the GRAASP, and the EPA's Guidance Document for Data Usability in Risk Assessment (EPA, 1990b). Elimination of the groups where historical data fits Case 2, requires an assessment of data quality, chemical fate and transport, and human and environmental risks posed by the chemicals (see Subsection 6.2.2). In addition, any historical release information and chemicals of concern at other OUs are evaluated. Assessment of chemical fate and transport and human/environmental risks allows a determination to be made as to whether the chemical is at a concentration in a specific media that poses an unacceptable risk to human health or the environment through a likely exposure pathway, and whether the chemical is likely to migrate to another medium at concentrations that also pose an unacceptable risk. For Case 3, continued monitoring for the analytical group in order to better characterize the media is justified, particularly for chemicals that are mobile and toxic.

The fate and transport of the contaminants likely to be found in OU 3 are discussed in Subsection 2.5.1.1.

Another factor in considering whether or not to analyze certain chemical groups is the toxicity of various chemicals in the media they are found. In this analysis, the concentrations of the chemical detected were compared to the Applicable or Relevant and Appropriate Requirements (ARARs). Appendix B, Tables B-1, B-2, B-4, and B-6, summarize the lowest potential ARARs for the chemicals detected in the groundwater, surface water, and sediments along Indiana Street. The action levels for sediments are based on the EPA's proposed RCRA Corrective Action Regulations (FR v.55, No. 145, July 27, 1990, 40 CFR 264.521). They are based on likely chemical exposure scenarios of a

10^{-6} incremental cancer risk (for carcinogens) or a no adverse health effect from a lifetime exposure to a systemic contaminant (noncarcinogen). The proposed action levels are for soils, not sediments, and are included for comparison purposes only. They are not considered ARARs.

6.2.2 Data Review Summary

The data reviewed for this evaluation were from three alluvial wells and one bedrock well along Indiana Street, three surface water locations at Walnut Creek, and Woman Creek located along Indiana Street, and sediment samples collocated with the surface water samples (Figure 6-1). The data were collected from 1987 to 1990. Results are tabulated by media and are summarized on Appendix B, Tables B-1 through B-7. Appendix B, Tables B-1, B-2, B-3, and B-4, summarize the compounds detected in groundwater, surface water, and sediment samples collected along Indiana Street. Appendix B, Tables B-5, B-6, and B-7, summarize all the compounds that were analyzed for but not detected for each of the media. A chemical was considered detected if the value was above the method detection limit or if it was qualified with a "J", indicating the presence of the chemical but below the method detection limit. Those values qualified with a "B" were not considered a detection. A "B" qualifier indicates the chemical was found in the laboratory QC blank and is probably associated with laboratory contamination rather than site-related.

The data quality and useability was also considered in the data review. Most of the water quality data were validated or acceptable with qualifications relative to guidance provided in the QAPP and GRAASP. However, high concentrations of acetone, butanone, and methylene chloride in the laboratory blanks in the 1987 investigations render it difficult to ascertain their presence in samples as an indication of site contamination. More recent validated data indicate they are not likely site contaminants in groundwater or surface water (EG&G, 1990e).

A summary of OU 3 analyses for groundwater, surface water, soils, and sediments is presented in Table 6-2. For groundwater wells, the samples will be analyzed for plutonium 239+240, americium 241, uranium 233+234, 235, 238, and cation/anions. The surface water samples will be analyzed for TCL volatile compounds in samples collected in Mower Reservoir only. All other surface water

TABLE 6-2

SUMMARY OF CHEMICAL ANALYSES FOR OU 3

Analyses	Ground Water	Surface Water[a]	Sediments	Soils
TCL VOA	NO - 2	NO - 2[b]	NO - 2[b]	NO
TCL Acid Extractable	NO - 1	NO - 1	NO - 1	NO
TCL Base/Neutral	NO - 1	NO - 2	NO - 2	NO
TCL Pest/PCB	NO - 5	NO[a] - 2	NO - 1	NO
Radionuclides	YES - 2	YES - 2	YES - 3	YES
TAL Metals	NO - 2	YES - 2	YES - 3	NO

Notes:
No–indicates analyses not necessary for OU 3.
Yes–indicates analyses necessary for OU 3.
1. CASE 1.
2. CASE 2, Further data not required.
3. CASE 2, Supplemental data required.
4. CASE 3, Data required.
5. No analyses performed for data set reviewed, but OUs 1 and 2 data indicate not present.

[a]Surface water samples will be analyzed for atrazine and simazine.
[b]Surface water and sediment samples from Mower Reservoir and associated drainages will be analyzed for volatiles.

samples will be analyzed for plutonium 239+240, americium 241, uranium 233+234, 235, 238, gross alpha, gross beta, and TAL metals. The sediment samples will be analyzed for TCL volatiles for Mower Reservoir only, and plutonium 239+240, americium 241, uranium 233+234, 235, 238, and TAL metals for all other sediment samples. The surface water and sediment samples along Walnut Creek will also be analyzed for tritium. The soil samples will be analyzed for the plutonium 239+240, americium 241, and uranium 233+234, 235, 238 isotopes. The rationale for each analysis is described in the following paragraphs and arranged by media.

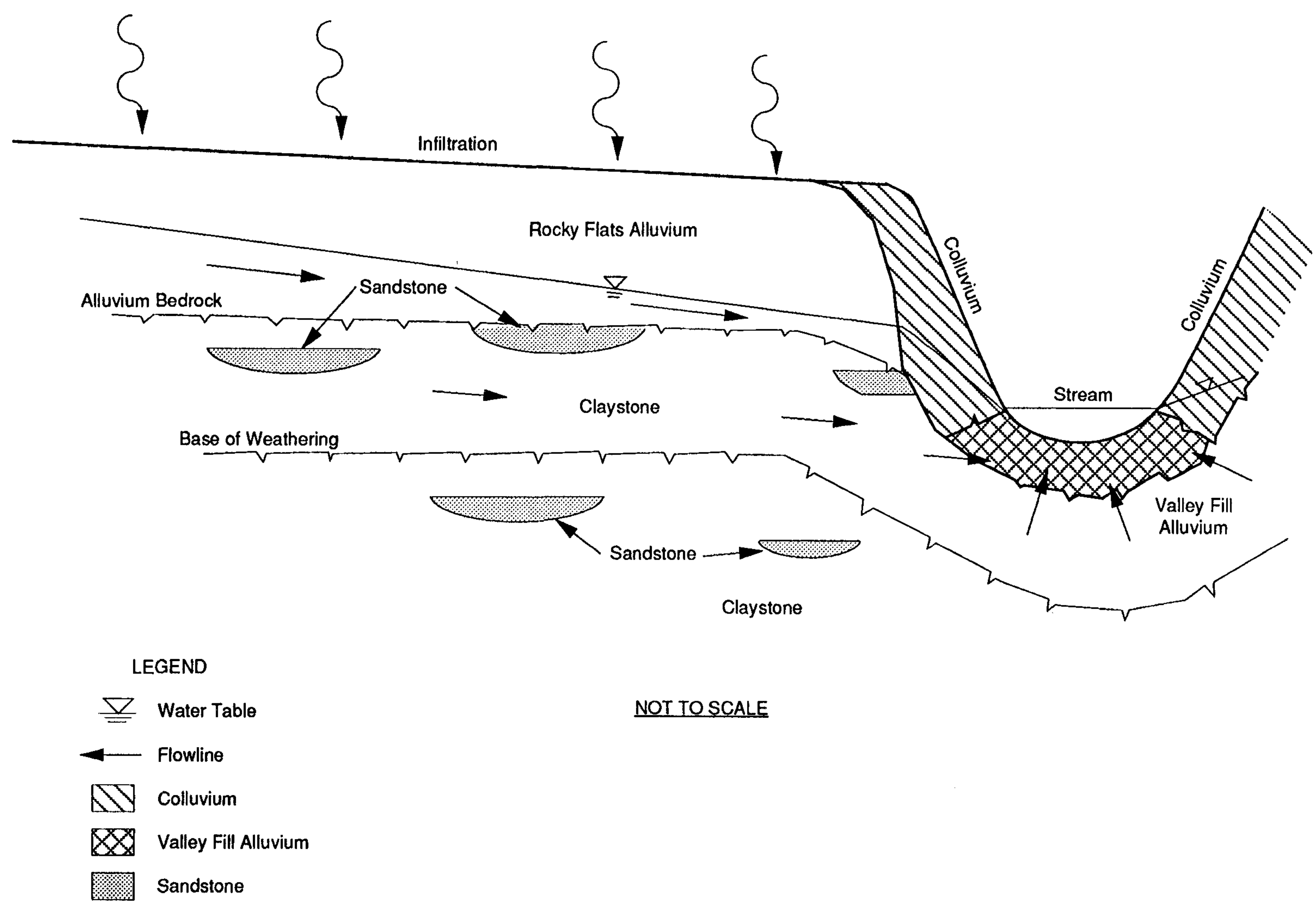
Miscellaneous analyses such as total organic content, bulk density, and cation/anions will be addressed in Subsection 6.3, Field Sampling Program.

6.2.2.1 <u>Groundwater</u>

Samples from the three alluvial groundwater wells and one bedrock well along Indiana Street were analyzed for volatiles, semivolatiles, radionuclides, and inorganic parameters from 1987 to 1990. A summary of the data evaluation and rationale for selecting analyses is provided in the following paragraphs.

Two groundwater flow systems have been identified within the Rocky Flats Plant: (1) a surficial flow system within the Rocky Flats Alluvium, colluvium, valley fill and weather bedrock; and (2) a bedrock flow system within unweathered bedrock sandstones. A schematic of the groundwater and surface water interaction is presented in Figure 6-2. The figure depicts conceptually how groundwater flows in the alluvium and colluvium discharges to the streams. The flow pathway for potential contaminants in the shallow groundwater system is to the stream drainages. In OU 3, site contaminants in groundwater can be assessed by sampling surface water and sediments in drainages exiting the Rocky Flats property.

6.2.2.1.1 Volatiles—Case 2. The volatile analyses fall into Case 2 with some low level and infrequent detections. Four volatile compounds were detected in the alluvial wells (Appendix B, Table B-1). The most frequently detected compound was methylene chloride (five detections out of



NOT TO SCALE

Source: Background Geochemical Characterization Report for 1989
(EG & G, December 21, 1990)

Figure 6-2
SCHEMATIC OF GROUND WATER/SURFACE WATER INTERACTION

DRAWN BY	Douville 6/19/91	CHECKED BY APPROVED BY	PBS A. Lange	x2516 6/21/91	DRAWING NUMBER	RF1010

36 analyses) followed by acetone (four detections out of 36 analyses). Both of these compounds are common laboratory artifacts. In addition, 1,1,1-trichloroethane was detected one time out of 44 analyses at a level of 9 µg/l. The MCL for 1,1,1-trichloroethane is 200 µg/l. Carbon disulfide was detected below the method detection limit one time out of 36 analyses. There is no MCL for carbon disulfide. In the bedrock well along Indiana Street (Appendix B, Table B-2), methylene chloride (seven detections out of 18 analyses) and carbon disulfide (two detections out of 18 analyses) were detected. The maximum values detected were 24 µg/l and 3 µg/l respectively. Methylene chloride is also a common laboratory artifact.

Appendix B, Table B-3 summarizes all the nondetected parameters in groundwater for both the alluvial and bedrock wells. The number of times the analyses were performed is also presented. Because the volatile compounds are not frequently detected and occur in such low levels, VOAs will not be analyzed in the proposed groundwater monitoring wells.

6.2.2.1.2 **Semivolatiles—Case 1**. The semivolatile analyses fall into Case 1. No semivolatile compounds were detected during two sampling events in the alluvial or bedrock wells located along Indiana Street. Very few semivolatiles were detected in OU 1 (one detection out of 141 analyses) and OU 2 (three detections out of 517 analyses). Therefore, analysis of semivolatile compounds is not necessary in OU 3.

6.2.2.1.3 **Pesticides/PCBs—Case 1.** Pesticides/PCBs were not detected during two sampling events in the wells along Indiana Street. In OU 1 there were no detections of pesticides or PCBs out of 121 analyses and for OU 2 there was one detection out of 401 analyses. There is no record of disposal of pesticides and PCBs at OUs 1 and 2. Because of the low and infrequent occurrences of pesticides and PCBs in the groundwater at OUs 1, and 2 and because they were not detected in the groundwater wells along Indiana Street, analysis of pesticides/PCBs is not necessary in the groundwater wells for OU 3.

6.2.2.1.4 **Radionuclides—Case 2.** The radionuclides fall into Case 2. Radionuclide activity in alluvial and bedrock groundwater was detected for plutonium 238+239+240, radium 226+228, strontium 90, and tritium in low levels (Appendix B, Tables B-1 and B-2). All activities for these isotopes were below MCLs. Gross alpha and beta were detected in levels above the MCL for several of the analyses. Because plutonium 239+240, americium 241, and uranium 233+234, 235, 238, have been identified as site-wide contaminants of concern, these radionuclides will be analyzed in the groundwater at OU 3. In addition, gross alpha and beta analyses will be performed.

6.2.2.1.5 **Inorganics/Metals–Case 2.** Metal analyses fall into Case 2. Metals were detected in groundwater with some exceedances of MCLs. Aluminum, barium, iron, manganese, strontium, and zinc were detected in more than 10 of the analyses (out of 28 analyses), with three of the metals exceeding MCLs (Appendix B, Table B-1) for the alluvial wells. Other metals were detected less frequently and were below MCLs for groundwater. In the bedrock well, aluminum, barium, iron, manganese, nickel, potassium, selenium, and strontium were detected more than 10 times out of 18 analyses. Some of the metal analyses are above MCLs. In evaluating groundwater quality, establishing background is important. Background conditions are evaluated in the Background Geochemical Characterization Report for 1989 (EG&G, 1990f). The primary pathway for metals migrating to groundwater at OU 3 is through the surface water and sediments as described in Subsection 6.2.2.1. If metals are determined to be a problem in surface water or sediments at OU 3, metals will be added to the analyte list.

6.2.2.2 Surface Water

Samples from the three surface water locations along Indiana Street were analyzed for volatiles, semivolatiles, pesticides/PCBs, of radionuclides, and inorganic parameters from 1987 to 1990.

6.2.2.2.1 **VOA–Case 2.** The volatile analyses for surface water fall into Case 2. Sixteen volatile compounds were detected in low levels and infrequently (Appendix B, Table B-4). Thirteen of the compounds were detected less than five times out of approximately 100 analyses. Methylene chloride was detected the most frequently with five occurrences; however methylene chloride is a common laboratory contaminant. Toluene was detected 8 (maximum value of 6 µg/l) times but in levels significantly lower than the MCL of 2,420 µg/l. None of the spurious detections occur above the MCLs. Appendix B, Table B-5, summarizes all the parameters that were not detected in the surface water samples. As described in the fate and transport section, volatile compounds readily undergo volatilization so it is unlikely volatiles would be detected at significant levels. The Standley Lake and Great Western Reservoir are sampled monthly and analyzed for volatile compounds. The cities of Westminster, Thornton, and Northglenn have eliminated VOAs from their sampling program as of January 1991 because there have been no detections. Since Mower Reservoir has not been sampled for volatiles, VOAs will be collected in Mower Reservoir. No VOA analyses will be performed at Standley Lake and Great Western Reservoir.

6.2.2.2.2 **Semivolatiles--Case 1 and 2.** No acid extractable compounds were detected out of 29 analyses in the surface water samples located along Indiana Street. There has also been no historical release of acid extractables at the site.

Four low detections of base/neutral compounds were detected in the surface water samples (Appendix B, Table B-4) out of 29 analyses. Bis(2-ethylhexyl) phthalate (10 detections out of 29 analyses) and Di-n-octyl-phthalate (2 detections out of 29 detections) were the only compounds detected more than once. The maximum level detected for Bis(2-ethylhevyl)phthalate was 19 µg/l, well below the MCL of 15,000 µg/l. Di-n-octyl-phthalate was detected twice with the maximum level of 3 µg/l. There is no MCL for Di-n-octyl-phthalate. In addition, at OU 2, there were only three detections of base/neutral extractables out of 3,240 analyses. Therefore, semivolatiles analyses are not necessary for the surface water samples collected for OU 3.

6.2.2.2.3 **Pesticides/PCBs--Case 2.** No TCL pesticides or PCBs were detected out of 28 analyses in the surface water samples. However, two herbicides were detected. Atrazine (eight detections out of 18 analyses) and simazine (two detections out of 17 analyses) were detected in low levels (Appendix B, Table B-4). The maximum value detected of atrazine was 2 µg/l, below the MCL of 3 µg/l. There is no surface water MCL established for simazine. At OU 2, there were three detections of pesticides/PCBs/herbicides out of 2,368 analyses. The three detections from samples at OU 2 were also for atrazine. The TCL pesticide and PCB analyses is not necessary for surface water samples at OU 3. However, the herbicides atrazine and simazine will be analyzed for in the OU 3 surface water samples.

6.2.2.2.4 Radionuclides--Case 2. Radionuclides were detected with low levels of activity and therefore are assigned Case 2. Plutonium, radium, strontium and tritium were detected in low levels (Appendix B, Table B-4). The activities detected are below MCLs for surface water. Gross alpha and beta were also detected. The surface water samples collected for OU 3 will be analyzed for plutonium 239+240, americium 241, uranium 233+234, 235, 238, gross alpha and beta since these are site-wide radionuclides of concern.

6.2.2.2.5 Inorganics--Case 2. Metals were detected in the surface water samples along Indiana Street and therefore are assigned to Case 2. Zinc, iron, manganese, lead, lithium, strontium and aluminum were detected more than 10 times out of approximately 80 analyses (Appendix B, Table B-4). Arsenic, beryllium, mercury, selenium, tin, vanadium and silver were detected five times or less out of approximately 80 analyses in the surface water. Several of the metals exceed MCLs for surface water. However, background water quality conditions are important in evaluating metals in surface water. Metal analyses will be performed on OU 3 samples and data will be compared to levels presented in the Background Geochemical Characterization Report for 1989 (EG&G, 1990f).

6.2.2.3 Sediments

Sediment samples were located at similar locations as the surface water samples along Indiana Street at Walnut Creek and Woman Creek. The sediment samples were analyzed for VOAs, semivolatiles, pesticide/PCBs, radionuclides, and inorganic compounds.

6.2.2.3.1 VOAs--Case 2. Four volatile compounds were detected out of 11 analyses in the sediments in low levels and infrequently, and, therefore assigned Case 2 (Appendix B, Table B-6). Acetone and methylene chloride were detected five times and two times, respectively, out of 11 analyses. These compounds are common laboratory artifacts. Toluene and 1,1,1-trichloroethane were detected one time at levels significantly below the proposed RCRA action levels of

20,000 mg/kg and 7,000 mg/kg, respectively. Volatiles have not been detected in significant levels in the sediments or surface water samples collected along Indiana Street. Since Mower Reservoir is the only reservoir not sampled for volatiles, VOAs will be performed for Mower Reservoir and its drainages.

6.2.2.3.2 Semivolatiles--Case 2. Six semivolatile compounds have been detected in the sediments at low levels and infrequently, and, therefore are assigned Case 2 (Appendix B, Table B-6). Five of the semivolatiles were detected once out of 11 analyses. Bis(2-ethylhexyl)phthalate was detected two times out of 11 analyses, but in levels significantly less than the proposed RCRA action limit of 50,000 μg/l. Semivolatile analyses will not be necessary in sediments for OU 3.

6.2.2.3.3 Pesticides/PCBs--Case 2. One pesticide was detected once in the sediment samples out of seven analyses. Beta-BHC was detected at 1.5 μg/kg. At OU 2 there were no detections out of 486 analyses. No pesticide/PCB analyses are necessary for sediments at OU 3.

6.2.2.3.4 Radionuclides--Case 2. Low levels of radionuclide activity have been detected in the sediment samples (Appendix B, Table B-6). Gross alpha and beta have been detected at 39 and 36 pCi/g, respectively. In addition, plutonium 238+239+240, radium 226+228, strontium 90, and tritium have been detected in the sediment samples. The sediment samples at OU 3 will be analyzed plutonium 239+240, americium 241, and uranium 233+234, 235, 238 and gross alpha and beta. Tritium will also be analyzed in sediment samples collected along Walnut Creek to characterize tritium in surface water from an accidental release of tritium in 1973.

6.2.2.3.5 Inorganics--Case 2. Metals have been detected in sediment samples, and, therefore are assigned Case 2 (Appendix B, Table B-6). Vanadium, aluminum, zinc, strontium, barium, lead, nickel, manganese, iron, copper, chromium, and arsenic have been detected more than five times out of 11 analyses in the sediment samples. To evaluate metals in sediments, establishing background levels is important. The metals in sediments will be evaluated based on a statistical comparison to background levels established in the Background Geochemical Characterization Report for 1989 (EG&G, December 21, 1990). Metals will be analyzed in sediments for OU 3.

6.2.2.4 Soils

Soil samples have been collected in the area and analyzed for plutonium, americium, and beryllium by the CDH. Beryllium has been analyzed in the 13 sectors sampled by the CDH in 1989. The results for beryllium in all sectors are below the method detection limit of 2.7 μg/kg. In addition, during the review of RFP records performed for the historical release report, a 1982 study of potential beryllium contamination in soils on and surrounding the RFP was performed. During the study, 243 samples were analyzed for beryllium. The conclusion of the study was that no surficial soils near the RFP were found to have detectable beryllium concentrations. Metals will also not be analyzed for in soil samples because no source for a metals release via the air pathway has been identified other than the fire which breached the exhaust filters of the beryllium-maching building and wind stripping of waste water from the solar evaporation ponds. The historical soil sampling for beryllium has indicated that beryllium is below detection limits and therefore has not been transported via the air pathway to the OU 3 soils. The solar evaporation ponds are a less plausible source of metals for OU 3. As stated previously, soil samples at the solar evaporation ponds will be collected and analyzed for TAL metals during the OU 4 field investigations. If metals are determined to be a potential source via resuspension to air and transported to OU 3 via wind, additional soil sampling will be performed and samples will be analyzed for metals detected during the OU 4 investigation.

The most likely pathway for release of metals from sources at the RFP is through surface water and sediment transport via the major drainages, Walnut Creek and Woman Creek. Metal analyses will be performed in surface water and sediment samples.

Soil samples have not been analyzed for volatiles, semivolatiles, pesticides/PCBs, or other inorganics in this area. Because of the high potential for volatilization of VOAs, it is unlikely VOAs have migrated far in soils (Section 2.5.1.1); therefore, no VOA analyses will be performed for the soil samples. Semivolatiles have not been detected in significant levels in the groundwater, surface water, and sediments at OU 1 and 2 or along Indiana Street; therefore semivolatile analyses will not be performed at OU 3. Pesticides and PCBs have also not been detected frequently at OU 1 and 2 and have not been detected at significant levels in the groundwater, surface water, and sediments along Indiana Street; therefore pesticides and PCBs will not be analyzed in the soils.

Based on the rationale described, soil samples will be analyzed for plutonium, americium, and uranium.

6.3 FIELD SAMPLING PROGRAM

This subsection describes the OU 3 RFI/RI field sampling program by media. The sampling plan associated with the environmental evaluation is presented in Section 8.0. As part of the field sampling program, the data from the sitewide monitoring program and other OU investigations will be used as appropriate to add to data collected during the OU 3 investigation as previously discussed. A number of SOPs will be used during the investigation. The SOPs are cited in this section and discussed further in Section 11.0 of this work plan.

6.3.1 Statistical Approach to Field Sampling Program

Historical data from sediment sampling along Indiana Street, Great Western Reservoir, and Standley Lake were reviewed to estimate the number of samples required. There exists a statistical relationship between confidence levels, powers, minimum detectable difference, coefficients of variation, and sample sizes. The Guidance for Data Useability to Risk Assessment (EPA, 1990b) defines these conditions as:

- Confidence level–100 minus the confidence level is the percent probability of taking action when no action is required (Type I error or false positive)

- Power–100 minus the power is the percent probability of not taking action when action is required (Type II error or false negative)

- Minimum Detectable Relative Difference–percent difference required between site and background concentration levels before the difference can be detected statistically

- Coefficient of Variation (CV)–the standard deviation divided by the mean.

The CV can be estimated from historical data. The confidence level and minimum detectable relative difference can then be defined and a curve of the power, varying by sample size, can be developed. A power curve can be used to calculate the number of samples needed to obtain a specific power. Historical data from several sources were used to generate power curves and estimate appropriate sample sizes for OU 3 sampling activities.

The historical data that were reviewed for estimating sample size for the sediments in the drainages were the sediment samples collected along Indiana Street at Woman Creek and Mower Ditch. For the reservoirs, sediment data collected from Great Western Reservoir and Standley Lake in 1983 and 1984 were reviewed (Rockwell, 1985c and 1984). For the surfacial soils, historical data from east of the buffer zone were reviewed. Power curves that vary by sample size were calculated and plotted for each of these data sets. The following statistics were calculated for each data set based on plutonium 239/240 data:

- Mean
- Standard deviation
- Coefficient of variation (i.e., standard deviation/mean).

The power curves were generated by setting a confidence of 80 percent and minimum detectable relative difference of 20 percent. The percent power then varies with the number of samples collected. The Guidance for Data Useability in Risk Assessment (EPA, 1990b) recommends a power of 90 percent and a confidence of 80 percent for risk assessment purposes. The evaluations based on limited historical data for the sediment drainages do not mean that the new data collected from OU 3 will necessarily meet a 90 percent power. When analytical results are close, or less than minimum, it is difficult to achieve a lower coefficient of variation because results are actually measuring the variability of the analytical methods and sampling techniques, and not actual contaminant concentrations. The program at OU 3 is striving for low CVs and powers of 90 percent, but these goals may not be achievable because plutonium concentrations in some of the media have been detected at levels less than, or close to, minimum detectable activity.

Historical data for surface water and air data fall into this category, which is less than or close to the minimum detectable activity.

As described in Section 2.0, the conceptual models for OU 3 have identified the soils and sediments as the primary sources for potential contaminant migration on OU 3. Therefore, the statistical discussions focus on these two media. It is important to note, however, that each pathway identified in the conceptual models presented in Section 2.0 is addressed in the field sampling programs presented in Subsection 6.2 and in Section 8.0 (field sampling program for the environmental evaluation).

6.3.1.1 Sediment Drainage Evaluation

Historical sediment data were available for sediments along Indiana Street at Woman Creek drainage and Mower Ditch. There is only one sample location at each drainage, but several sample events are available at each location. Historical sediment data were not available for sediments along Walnut Creek at Indiana Street. The CV for Walnut Creek was estimated to be the same as the Mower Ditch CV (the higher CV between the two drainages). Historical data at Woman Creek and Mower Ditch showed CVs of 25 and 30 percent, respectively.

The power curves generated for Woman Creek, Mower Ditch, and Walnut Creek are presented in Appendix C. To achieve a 90 percent power, 10 samples are estimated for Walnut Creek and Mower Ditch, and eight samples are estimated for Woman Creek.

In the OU 3 sample program for sediment drainages 10 samples in the Walnut Creek drainage basin area will be collected. At Mower Reservoir, five samples along the Mower ditch will be collected and five near-shore sediment samples will be collected, for a total of 10 samples. Because Mower Reservoir is fed solely by the Mower Ditch, grouping the drainage sediments with the near-shore sediments is reasonable. Ten samples will be collected in the Woman Creek drainage. The specific sample locations and sampling procedures for the drainage sediment sampling are discussed in Subsection 6.3.3.

6.3.1.2 Sediment Reservoir Evaluation

In 1983 and 1984, sediment studies were performed in both Great Western Reservoir and Standley Lake (Rockwell, 1985c and 1984). At Great Western Reservoir, 42 random sediment samples were collected. Fifty-six samples were collected at Standley Lake. The mean, standard deviation, and CV were calculated and power curves were generated for both data sets.

Power curves for the data sets are presented in Appendix C. To achieve an 80 percent power, 62 samples are estimated for Great Western Reservoir. In Standley Lake, 56 samples are estimated to achieve an 80 percent power. To achieve these power levels, samples will be collected from each reservoir in an attempt to verify the historical data. The number of samples needed to verify the historical data is based on the hypergeometric distribution (Mendenhall, et al, 1981). The hypergeometric distribution assumes that no more than 10 percent of the data will be greater than the historical data with a confidence of 90 percent. The number of samples needed for Great Western Reservoir and Standley Lake based on the hypergeometirc distribution are presented in the following paragraphs.

At Great Western Reservoir, 15 random reservoir sediment samples will be collected at locations similar to where samples were collected in the 1983 study. If the concentrations are less than or equal to the 1983 data, the 42 sediment samples will be used in the evaluations to try to achieve a power of 80 percent. An additional 15 samples will also be collected from the exposed shoreline sediments along Great Western Reservoir. This will increase the sample size to 72 samples to strive for a power of 80 percent.

At Standley Lake, 18 random grab samples will be collected in an attempt to verify the 1984 sampling. If the concentrations observed are less than or equal to the 1984 data, then the 56 samples will be used in evaluations to try to achieve a power of 80 percent. An additional 15 samples will be collected from the shoreline sediments around Standley Lake. This will increase the sample size to 89 samples. This corresponds to a power of 88 percent, based on the historical results.

After the samples are analyzed and the results are validated, the data will be compared by using the Sign test. The Sign test is a nonparametric test where the data are treated as pairs. The hypothesis being tested is that the historical data is greater than or equal to the present day data collected. The null hypothesis is that the median of the population of all possible differences is zero. The alternative hypothesis is that the median difference is not equal to zero and means the historical concentrations are more likely to exceed the present day concentrations.

If the null hypothesis is rejected and the alternative hypothesis is accepted, then the historical concentrations are likely to exceed the present day concentrations most of the time. If the null hypothesis is accepted and the present day concentrations are not more likely to exceed the historical concentrations, then the data sets are assumed to be similar. If the null hypothesis is accepted and the present day concentrations exceed the historical data, then additional sampling may be required to achieve the appropriate power and confidence limits.

Details of the sampling program for sediments in reservoirs are presented in Subsection 6.3.3.

6.3.1.3 Surficial Soils Evaluation

The historical surficial soil data was evaluated and a power curve was generated. The power curve is presented in Appendix C. A power of 70 percent will be achieved with a sample size of 50, based on the historical data. The sample size of 50 is a conservative estimate because each composite sample consists of 25 subsamples. Ten additional soil samples will also be collected at more distal areas to provide a sample size of 60. Fifty-six soil samples collected on the remedy acreage in January 1991 from both tilled and untilled Jefferson County acreage may also be included in the surficial soil evaluations. The soil results have a high coefficient of variation, making it difficult to achieve a power of 90 percent.

Details of the sampling program for soils are presented in Subsection 6.3.2.

6.3.2 Soil

The purpose of the soil sampling program is to characterize the vertical and lateral extent of plutonium, americium, and uranium contamination in OU 3. Because of the prevailing wind conditions and results from previous investigations, the OU 3 areas with the highest plutonium concentrations are believed to be east of the Rocky Flats buffer zone boundary, east of Indiana Street.

6.3.2.1. Soil Profile Sampling

Two soil sampling activities will be performed. The first activity is soil profile sampling. The purpose of the profile sampling is to characterize vertical plutonium, americium, and uranium concentrations in the soils. Sampling locations were selected by reviewing historical aerial photographs and conducting a site reconnaissance to identify undisturbed areas. The undisturbed areas have the highest potential for accumulation of contaminants. Eleven profile samples will be collected from undisturbed areas identified from the photos as shown on Figure 6-3.

A description of the type of land use and vegetation cover at each sample location will be included in the field notebooks. Vertical profile samples will be collected following the method used at OUs 1 and 2. This method consists of collecting 11 samples at various depths at each location according to the following sample scheme:

- The upper 12 cm will be sampled in 3 cm intervals at 0, 3, 6, 9, and 12 cm
- The next 12 cm will be sampled in 6 cm intervals at 18 and 24 cm
- The next 24 cm will be sampled in 12 cm intervals at 36 and 48 cm
- The deepest 48 cm will be sampled in 24 cm intervals at 72 and 96 cm.

The samples will be collected by digging a trench with a backhoe or shovel 1.5-meter long, 1.0-meter wide, and 1.0-meter deep. One wall of the trench will be dug as a block/staircase with each stair step being 15 cm in height. The stair-step wall helps minimize cross contamination of soils with depth. The vegetation at the surface of the selected wall will be cropped closely to the surface and discarded. The soil will be sampled at the appropriate interval starting at the deepest block/stair in a given pit. The soil morphology and sampling of test pits will be performed according to the SOP addenda presented in Section 11.0. Soil samples will be collected using a stainless steel scoop and template (3 cm x 20 cm), which will be pressed into the wall of the block/staircase. Three samples from each depth will be composited to provide a better representation of the site. After a sample has been collected, soil layers below it will be cleared of sloughed material to prevent possible contamination from the upper soil layers. A flag will be placed on the ground surface of a given pit, and the depth below surface for each sample will be measured from the base of the flag. Each pit will be backfilled with the original soil mixture removed during the excavation.

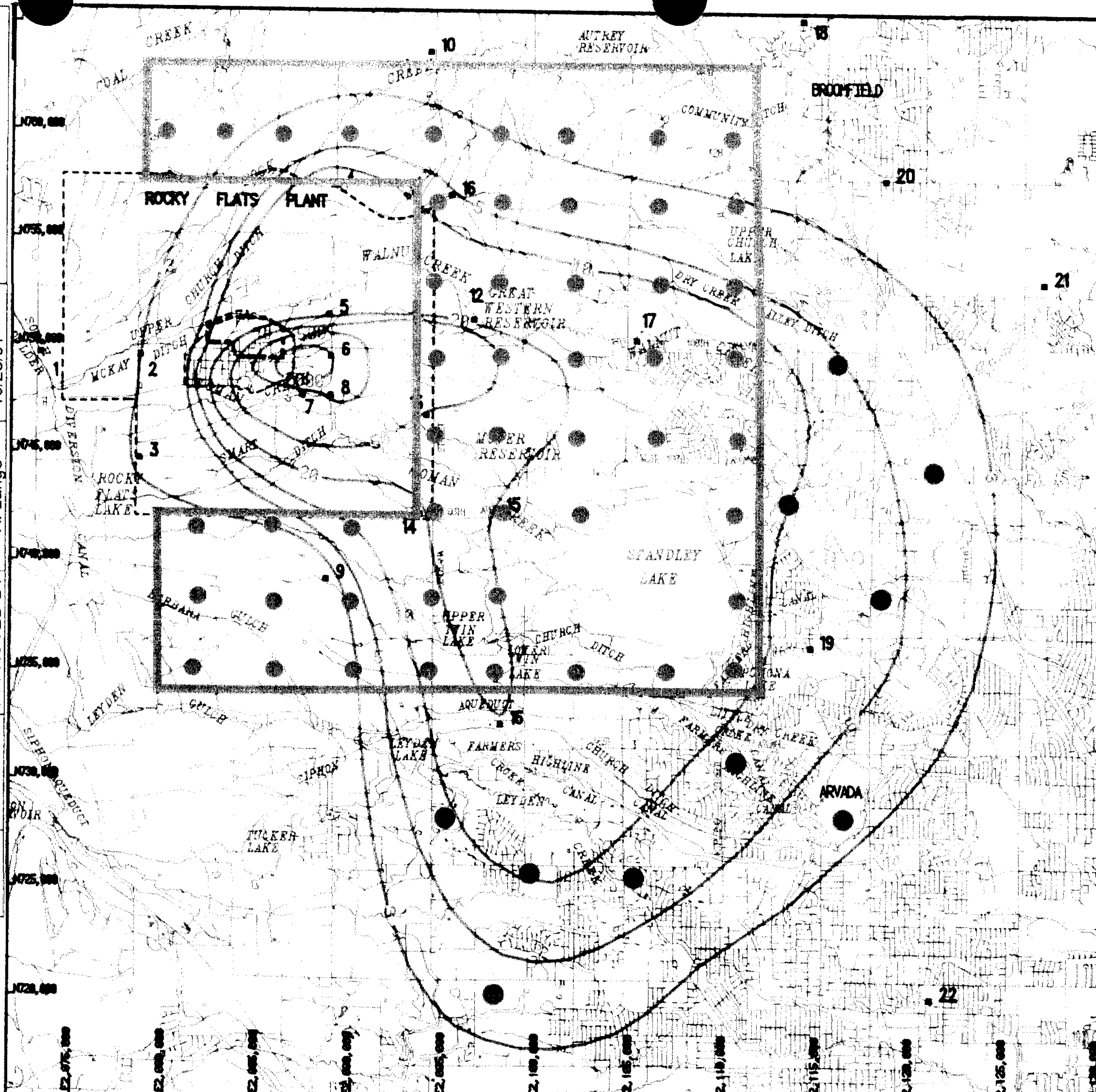
The samples will be analyzed for plutonium, americium, and uranium. Ten percent of the samples will also be analyzed for total organic carbon (TOC), bulk density, and grain size. Information regarding sample analysis and field quality control samples is summarized in Subsections 6.4 and 6.5 of this document, respectively.

geostatistical analysis was performed by EG&G and is summarized in Appendix D of this document. The soil plutonium concentrations east of Indiana Street were kriged using an exponential model. Plutonium concentrations higher than the recommended CDH special construction requirements standard of 0.9 pCi/g were observed only near the eastern boundary of the RFP. The concentrations of plutonium decreased rapidly with distance. By using a maximum acceptable error of 0.41 pCi/g, which seems reasonable based on the CDH standard, an equivalent kriging variance of 0.168 was used in predicting optimal sample spacing. Based on this variance an optimal sampling interval of 1,750 meters was calculated.

These calculations were based on the RFP soil-sampling technique where five subsamples were collected from the corners and the center of two 1-m squares, which were 1 m apart. Surfacial soil-sampling for plutonium in soils at OU 3 will follow the procedure recommended by CDH. This method allows for the top 1/4-in of soil to be sampled. The top 1/4-in of soil can most easily be dispersed by wind and potentially leads to inhalation, direct contact, and ingestion by people. This soil-sampling technique recommends the collection of 25 subsamples from a 10-ac plot within a specified parcel of land to yield a single composite sample. The sampling locations should be more or less evenly spaced within the area. The difference in area between the RFP soil sampling and the CDH sampling techniques introduces some uncertainty in the optimal spacing calculations. Therefore, the optimal spacing will be reduced from 1,750 to 1,000 m.

As stated in Subsection 2.1.4.2, attempts were made by Krey and Hardy (1970) and Dow Chemical (DOW, 1971) to establish plutonium contours surrounding the RFP. A grid approximately 3 by 5 mi located east of the RFP boundary has been overlaid on the Krey and Hardy map showing plutonium contours in the vicinity of the RFP. The grid encompasses the three IHSS reservoirs (Great Western, Mower, and Standley Lake) and most areas within the 10 mCi/km^2 (approximately 1 pCi/gm) contour developed by Krey and Hardy. The grid also extends north and south of the RFP buffer zone. Approximately fifty 10-ac plots will be sampled within the grid (Figure 6-4).

The grid does not encompass areas located to the west of the 903 Pad (source of plutonium and americium contamination for OU 3) because previous studies indicate that prevailing wind conditions



MAP LEGEND

- - - RFP Boundary and PSZ

Contour Values in mCi per Km²

■ Numbered Sampling Sites

● Soil Grid Sample Locations (plutonium, americium, and uranium analyses) - Each Sample Location is a 10 Acre Plot where 25 Subsamples will be Collected to Form 1 Composite Sample (CDH Method)

● Samples Outside of Soil Grid

0 3400 6800
SCALE IN FEET

Figure 6-4
Approximate Soil Sampling Locations for Soil Survey (Plutonium-239 Contours Krey and Hardy, 1970)

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6.3.3 Sediment

The sediment sampling activities proposed for OU 3 consist of sampling drainages/ditches, reservoirs, and near-shore sediments. Drainages/ditches are a potential pathway for offsite migration. Exposed sediments, in turn, are a potential pathway of dispersion of contaminants by wind.

6.3.3.1 Sediment Samples in Drainages/Ditches

To characterize the extent of contamination in drainage ditches, the following sediment samples will be collected (see Figure 6-5):

- Seven sediment samples above and below Great Western Reservoir along Walnut Creek Drainages
- Two samples along Broomfield Diversion Ditch
- Five samples above and below Mower Reservoir
- Seven samples above Standley Lake along Woman Creek Drainages
- Two samples along Church Ditch
- Two samples along unnamed drainages east of Indiana Street
- One sample near the inlet of Clear Creek Irrigation Ditch
- Two samples along Smart Ditch
- One sample along Big Dry Creek below Standley Lake.

6.3.3.2 Sediment Samples in Reservoirs

Reservoir sediment samples will consist of two types: sediment samples located near the shoreline that may potentially be exposed during low reservoir capacity and samples collected from within the deeper areas of the reservoir.

6.3.3.2.1 Near-shore Reservoir Samples. The near-shore reservoir sediment samples will be collected to characterize sediments that potentially may be exposed during low reservoir capacity. The exposed sediments may be dispersed by wind, which potentially leads to inhalation, dermal contact, and ingestion by people. Previous sampling activities for sediments have not been focused along the shoreline of the reservoirs.

Samples will be collected in exposed sediments around each reservoir. Fifteen samples will be collected around both Great Western Reservoir and Standley Lake. Five samples will be collected around Mower Reservoir. The statistical rationale for the numbers of samples was presented in Subsection 6.3.1. Sample collection will occur when the reservoir is anticipated to be at its lowest capacity and will be determined from historical storage records for Great Western Reservoir and Standley Lake. Figure 6-5 presents the near-shore sediment sample locations.

The near-shore sediment samples will be grab samples collected similar to the site-wide sample collection method. Procedures described in SOP No. 4.6 will be followed. The samples will be analyzed for plutonium, americium, uranium, gross alpha and beta, and TAL metals. The near-shore sediment samples around Mower Reservoir will also be analyzed for TCL volatiles. Ten percent of the samples will be analyzed for TOC, bulk density, and grain size.

Sedimentation rates from the near-shore areas have been estimated to be less than 0.1 in/year (Historical Information Summary, Battelle, 1981a). Therefore, to obtain a vertical profile of concentrations of plutonium, americium, and uranium with depth from sediments that may have accumulated from 1950 to present, a 4-in sediment core is necessary. One near-shore vertical profile sediment sample from each reservoir will be collected in addition to the grab samples the reservoir sediments (15 samples at Great Western Reservoir, five at Mower Reservoir,and 18 at Standley Lake). The samples at Great Western Reservoir and Standley Lake will be taken near historical locations selected randomly so a comparison between the data sets can be made (see Subsection 6.3.1). Approximate grab sample locations are shown in Figure 6-5. The gravity core sampler will be used for sample collection, but the core recovered will be composited into one sample and analyzed for plutonium, americium, uranium, gross alpha and beta, and TAL metals. Reservoir sediment samples in Mower Reservoir will also be analyzed for TCL volatiles. Ten percent of the grab samples will also be analyzed for TOC, bulk density, and grain size. The procedures for sampling will generally follow SOP No. 4.6. Variations to the SOPs are described in Section 11.0 of this work plan.

6.3.4 Surface Water

The surface water program for the OU 3 RFI/RI is designed to characterize plutonium, americium, uranium, and TAL metals in surface water. To accomplish this goal, surface water samples will be collected at locations in Great Western Reservoir, Mower Reservoir, and Standley Lake. The program is also designed to evaluate past investigations at the reservoirs. Great Western Reservoir and Standley Lake are routinely monitored by CDH, the cities of Broomfield, Westminster, Thornton, and Northglenn. Therefore, an extensive surface water monitoring program is not required. Results from these monitoring activities will be incorporated into the quantitative baseline risk assessment.

6.3.4.1 Surface Water Drainages/Ditches

The surface water drainage/ditch investigation will focus on the existing monitoring stations along Indiana Street (SW001, SW002, and SW003). These locations represent the areas where contaminants entering OU 3 would likely be the highest levels. The monitoring stations along Indiana Street are sampled quarterly for volatiles, semivolatiles, radionuclides, including tritium, metals, and pesticides and PCBs. In addition to the monitoring along Indiana Street, several other surface drainage/ditch locations will be sampled (Figure 6-6). One surface water sample will be collected in the Broomfield Diversion ditch. One surface water sample will also be collected near the concentration because of reservoir conditions. High and low capacities will be identified based on historical capacity of reservoirs.

6.3.5 Groundwater

A limited groundwater field investigation will be performed at OU 3. Currently, 14 wells in the eastern buffer zone are sampled on a quarterly basis as part of the RFP site environmental monitoring program. Four of these wells are located along Indiana Street (Figure 6-7). The groundwater monitoring wells are analyzed for total dissolved solids, anions, CLP target compounds (volatiles and semivolatiles), oil and grease, metals, and radionuclides. These wells are located upgradient of OU 3, but downgradient of the RFP source areas. The results to date from the RFP boundary wells have not detected contaminants (Historical Information Summary and Preliminary Health Risk Assessment DOE, 1991b). Therefore, no contaminants are believed to be leaving the RFP through the groundwater pathway. Data from the buffer zone wells will continue to be reviewed quarterly during the implementation of the OU 3 work to identify if contaminants are detected in these wells. If contaminants are detected, an expanded groundwater field investigation will be developed.

The purpose of the groundwater investigation is to obtain site-specific hydrogeology in the vicinity of Great Western Reservoir and Standley Lake and to assess impacts on groundwater from potential contamination that has been dispersed offsite to OU 3 through the drainages and reservoirs. Groundwater sampling will also identify potential contamination in the groundwater from sediment/ groundwater interactions and surface water/groundwater interactions, if present.

Two groundwater monitoring wells will be located downgradient of both Great Western Reservoir and Standley Lake. One well will be installed and completed in the unconfined alluvial system and one well will be completed in the confined Arapahoe formation at both locations. The shallow alluvium wells will be drilled according to SOP No. 3.2, logged according to SOP No. 3.1, installed according to SOP No. 3.6, and developed according to SOP No. 2.2. The alluvial wells are estimated to be approximately 20 to 30 ft deep.

6.3.6.1 Wind Tunnel Study

A special wind tunnel study will be conducted as an in situ measure of particle resuspension. The tunnel was developed to measure particle matter emissions from open waste piles. The method is an in-depth technique used to directly measure the emission rates of erodible materials. The basic technique is founded on guidance provided in Subsection 4.2.4–Portable Wind Tunnels (in-depth technique)–of the Air/Superfund National Technical Guidance Study Series, Volume II, Estimates of Baseline Air Emissions at Superfund Sites, EPA-450/1-89-002a, August 1990.

The instrument has an open-floored test section, which is placed directly over the surface to be measured. Air is drawn through the test section at controlled velocities simulating winds at any given height. The air stream passes through a duct fitted with a sampling probe at the downstream end. Air is drawn from this probe isokinetically by a high volume air sampling. The sampler will be fitted with a cyclone precollector and a cascade impactor.

Three areas have been selected for wind tunnel tests, the shore at Standley Lake, the shore at Great Western Reservoir, and a vegetated area of OU 3. Approximately six tests will be conducted at each of these study areas to characterize the site. Each test consists of measurements made at three predetermined wind speeds.

This study is designed to provide data for use in risk assessments and overall site characterization. The data from this study will address particle size distributions relative to wind speed, and concentrations of suspended material by particle size (specific to the test area).

6.3.6.2 Air and Meteorological Monitoring

The purpose of the air and meteorological monitoring plan is to collect onsite data for use in both present and future risk assessments.

6.5 SAMPLE ANALYSIS

This section describes the sample handling procedures and analytical program for samples collected during the OU 3 RFI/RI. This section discusses sample designations, analytical requirements, sample containers and preservation, and sample handling and documentation.

6.5.1 Sample Designations

All sample designations generated for this RFI/RI will conform to the input requirements of the RFEDS. Each sample designation will contain a nine-character sample number consisting of a two-letter prefix identifying the media samples (such as, "SB" for soil borings, "SS" for stream sediments), a unique five-digit number, and a two-letter suffix identifying the contractor (such as, "CH" for CH2M HILL). One sample number will be required for each sample generated, including QA/QC samples. In this manner, 99,999 unique sample numbers are available for each contractor that contributes sample data to the data base. A block of numbers will be reserved for the OU 3 RFI/RI sampling. Boring numbers will be developed independently of the sample number for a given boring. Specific sample location numbers will be assigned when the detailed sampling plans are developed.

6.5.2 Analytical Requirements

Generally, all samples from the RFI/RI will be analyzed for plutonium 239/240, americium 241, and uranium 233/234, 235, 238. The surface water and sediment samples will also be analyzed for TAL metals. Surface water and sediment samples from Mower Reservoir will be analyzed for TCL volatiles.

The specific analytes in the groups listed above and their detection/quantitation limits for water and for soil/sediment are contained in Table 6-3. The specific OU 3 analytical programs are contained in Table 6-4. Both filtered and unfiltered samples for the surface water and groundwater samples will be collected and analyzed for radionuclides and for surface water TAL metals.

TABLE 6-3

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS AND THEIR DETECTION LIMITS OPERABLE UNIT NO. 3

TARGET ANALYTE LIST—METALS	DETECTION LIMITS[1] Water (µg/l)	Soil/Sediment (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1.0
Cadmium	5	1.0
Calcium	5,000	2,000
Cesium	1,000	200
Chromium	10	2.0
Cobalt	50	10
Copper	25	5.0
Cyanide	10	10
Iron	100	20
Lead	5	1.0
Lithium	100	20
Magnesium	5,000	2,000
Manganese	15	3.0
Mercury	0.2	0.2
Molybdenum	200	40
Nickel	40	8.0
Potassium	5,000	2,000
Selenium	5	1.0
Silver	10	2.0
Sodium	5,000	2,000
Strontium	200	40
Thallium	10	2.0
Tin	200	40
Vanadium	50	10.0
Zinc	20	4.0

TABLE 6-3

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS AND THEIR DETECTION LIMITS OPERABLE UNIT NO. 3 (Continued)

	QUANTITATION LIMITS[1]	
TARGET COMPOUNDS LIST-VOLATILES (Continued)	**Water (μg/l)**	**Soil/Sediment (μg/kg)**
4-Methyl-2-pentanone	10	10
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Xylenes		
HERBICIDES		
Atrazine	10	670
Simazine	10	670

	REQUIRED DETECTION LIMITS[1]	
RADIONUCLIDES	**Water (pCi/ℓ)**	**Soil/Sediment (pCi/g)**
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235, and 238 (each species)	0.6	0.3 dry
Americium 241	0.01	0.02 dry
Plutonium 239+240	0.01	0.03 dry
Tritium	400	400 (pCi/ml)

TABLE 6-4

ANALYTICAL PROGRAM FOR OPERABLE UNIT NO. 3

Sample Activity	Media	Pu 239/240	Am 241	U 233/234	U 235	U 238	H3[1]	Gross ∝
Profile soil sampling	Soil	X	X	X	X	X		
Soil grid survey	Soil	X	X	X	X	X		
Sediment sample in drainages	Sediment	X	X	X	X	X	X	X
Sediment sample near reservoir shoreline	Sediment	X	X	X	X	X		X
Reservoir vertical profile sediment samples	Sediment	X	X	X	X	X		
Reservoir grab sediment samples	Sediment	X	X	X	X	X		X
Surface water samples in drainages	Water	X	X	X	X	X		X
Surface water samples in reservoirs	Water	X	X	X	X	X		X
Groundwater monitoring wells	Water	X	X	X	X	X		X
Wind tunnel and ultra-high volume air samples	Air	X	X	X	X	X		

[1]Samples collected along Walnut Creek only.
[2]Ten percent of the samples.
[3]Mower Reservoir and associated drainages only.

The soil matrices to be analyzed will include soils and sediments. The water matrices for analysis will include surface water and groundwater. Tables 6-5 and 6-6 list analytical parameters of interest in OU 3 for water and soil matrices, along with the associated container size, preservatives (chemical and/or temperature), and holding times. Additional specific guidance on the appropriate use of containers and preservatives is provided in SOP No. 1.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples.

6.5.4 Sample Handling and Documentation

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field. Accountable documents include logbooks, data collection forms, sample labels or tags, chain-of-custody forms, photographs, and analytical records and reports. Specific guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in SOP No. 1.14.

6.5.5 Data Reporting Requirements

Field data will be input in to the RFEDS using a remote data entry module supplies by EG&G. The data will be put through a prescribed QC process based on SOP No. 1.14 to be generated by EG&G. A sample tracking spreadsheet will be maintained by the contractor for use in tracking sample collection and shipment. Computer and data security will also follow acceptable procedures outlined by EG&G.

6.6 FIELD QC PROCEDURES

Sample duplicates, bottle blanks, equipment rinseate blanks and performance evaluation samples will be prepared. Trip blanks will be obtained from the laboratory. The analytical results obtained for these samples will be used by the data users to assess the quality of the field sampling effort. The types of field QC samples to be collected and their applications are discussed below. The frequency for QC samples to be collected and analyzed is provided in Table 6-7.

TABLE 6-6

SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR SOIL SAMPLES OPERABLE UNIT NO. 3

Parameter	Container	Preservative	Holding Time
SOIL OR SEDIMENT SAMPLES—LOW TO MEDIUM CONCENTRATION			
Organic Compounds			
Purgeable Organics (VOCs)	1 x 4-oz wide-mouth teflon lined glass vials	Cool, 4°C	14 days
Inorganic Compounds			
Metals (TAL)	1 x 1-oz wide-mouth glass jar	Cool, 4°C	180 days[1]
Cyanide	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
Radionuclides	1 x 1-L wide-mouth glass jar	None	45 days

[1]Holding time for mercury is 28 days.

Source: (DOE, 1991c).

Duplicate samples will be collected and will be used as a relative measure of the precision of the sample collection process. These samples will be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples.

Bottle blanks of distilled water, preserved according to the preservation requirements (Subsection 6.5.3), will be used to provide an indication of any contamination introduced from the sample bottles. As indicated by Table 6-4, these QC samples are applicable only to samples requirement chemical preservation.

Equipment (rinseate) blanks will be collected from final decontamination rinseate to evaluate the success of decontamination efforts on nondedicated sampling equipment. Equipment blanks are obtained by rinsing cleaned equipment with distilled water before sample collection. The rinseate is collected and placed in the appropriate sample containers. Equipment rinseate blanks are applicable to all analyses for water and soil samples as indicated in Table 6-7.

Trip blanks consisting of deionized water will be prepared by the laboratory technician and will accompany each shipment of water samples for volatile organic analysis. Trip blanks will be stored with the group of samples with which they are associated. Analysis of the trip blank will indicate migration of volatile organics or any problems associated with the shipment, handling, or storage of the samples.

Performance evaluation samples will be prepared that contain known compounds and will be sent to the laboratory for analysis to monitor laboratory and method performance. Performance evaluation samples are used to evaluate accuracy.

Procedures for monitoring field QC are given in the sitewide QAPP. In addition, information regarding the collection of matrix spike and matrix spike duplicates for laboratory quality control are included in the QAPP.

7.0 HUMAN HEALTH RISK ASSESSMENT PLAN

7.1 OVERVIEW

7.1.1 Regulatory Basis

Section 300.430(d) of the National Contingency Plan (Federal Register March 8, 1990, p. 8709) states that as part of the remedial investigation, a human health risk assessment is to be conducted to determine whether contaminants of concern identified at the site pose a current or potential risk to human health and the environment in the absence of remedial action. This section describes the Human Health Risk Assessment components, including the following:

- Contaminant description
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis.

Figure 7-1 illustrates the basic Human Health Risk Assessment process and components. The objective of this assessment is to identify and estimate potential human health risks resulting from exposure to site contaminants present in various environmental media. The Human Health Risk Assessment considers risks from both radiological and nonradiological contaminants. The EPA and DOE require a two-phase evaluation for the radiological portion of the assessment. The Human Health Risk Assessment will incorporate the two-phase analysis, which includes:

- Procedures established by the International Commission on Radiological Protection (ICRP) and adopted by the EPA used to estimate the radiation dose equivalent to humans from potential exposure to radionuclides through all pertinent exposure pathways

- Estimates of health risk, based on the age-averaged lifetime excess cancer incidence per unit intake (and per unit external exposure) for radionuclides of concern.

Human Health Risk Assessment results will be used to determine if remedial actions are warranted at OU 3 and, if so, what associated cleanup levels will be necessary to protect human health.

A number of guidance and information documents will be used to provide direction for developing the Human Health Risk Assessment. These include:

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Volume 1. (Part A). Interim Final. 1989. EPA/540/1-89/002 (EPA, 1989c), including OSWER Directive 9285.6-03 Human Health Evaluation, Supplemental Guidance: "Standard Default Exposure Factors"

- Guidance for Data Usability in Risk Assessment. Interim Final. 1990. EPA/540/G-90/008 (EPA, 1990b)

- Superfund Exposure Assessment Manual. 1988. EPA/540/1-88/001 (EPA, 1988b)

- Procedures established by the ICRP and adopted by EPA in Federal Guidance Report No. 11 (EPA, 1988)

- Radiation Protection of the Public and the Environment, DOE Order 5400.4

- Risk Assessment in the Federal Government: Managing the Process. 1983. National Academy Press, Washington, D.C.

The preliminary qualitative assessment used existing information to make judgements concerning the potential exposure pathways and to identify the plausible exposure pathways and qualitative risks that are applicable to the following scenarios:

- No further action for current land use scenario
- Implement the remedy (workers and public) for the current land-use scenario
- Past remedy for current and future land-use scenarios.

These judgements are not used to eliminate potential exposure pathways from evaluation in the RFI/RI.

The preliminary risk assessment for the no further action alternative and the remedy implementation alternative were based on the current recreational land use condition for IHSS 199. A hypothetical risk assessment used generic exposure pathway assumptions based on a future residential land use. Only plutonium risk was assessed based on soil concentrations of 1, 10, and 100 pCi/g. These concentration values provide a range of risks from 7 X 10^{-7} to 7 X 10^{-8} (DOE, 1991a) for the current recreation exposure scenario. Using a residential setting, the theoretical calculated generic risk assessment for Pu-239 yielded a range of risks for 2 X 10^{-5} to 2 X 10^{-7}.

As indicated in Table 7-1, risk incurred from exposure to plutonium-239 in a recreational exposure scenario at IHSS 199 before, during, and after remedial activities would be below EPA's target range of acceptable risk (i.e., below 1 X 10^{6}). Residential use exposure cannot occur at IHSS 199 before or during the remedy activities.

Table 7-1 summarizes the hypothetical qualitative risk characterization derived from the generic risk assessment. The generic risk assessment is based on a hypothetical multipathway exposure scenario. All exposure pathways use plutonium-239 in soil as the source media. The following two scenarios and component pathways are considered.

Residential	**Recreational**
Incidental Soil Ingestion	Incidental Soil Ingestion
Inhalation of Dust	Inhalation of Dust
Ingestion of Leafy Vegetables	
Ingestion of Tuber Vegetables	
Ingestion of Beef Tissue	
Ingestion of Beef Liver	
Ingestion of Cow's Milk	

All of the data reviewed indicate that radionuclides in sediments are the only contaminants of concern at IHSS 202-202 that can be attributed to RFP historical releases. Some media specific analyses of plutonium and other radionuclides present at the RFP, such as americium-241, have been performed at Great Western Reservoir and Standley Lake. However, only plutonium was addressed specifically in the qualitative and the general risk assessments, because the potential exposure pathways for the radionuclides of concern are similar (although significance may vary), and significantly more data would be needed to quantitatively address the risks of these other radionuclides. A more comprehensive assessment of all contaminants of concern and of the potential exposure pathways will be performed during the scheduled RFI/RI activities.

The preliminary risk assessment for IHSS 200-202 was based on hypothetical plutonium concentrations in reservoir sediments and water under various exposure scenarios. The added lifetime excess cancer risk for all potentially exposed members of the public would range from 7×10^{-9} to 7×10^{-6} based on soil concentrations of 0.01, 0.1, 1, and 10 pCi/g (DOE, 1991a).

Data needs and DQOs were presented in Section 5.0 of this work plan. Section 6.0 of this work plan described how the data needs identified will be collected. The data needs and FSP address the objectives described in Subsection 5.1.4 and include characterizing the nature and extent of contamination and the data collection necessary to assess the complete potential exposure

- **SED-3:** Data characterizing sediments that may be potentially exposed during low reservoir capacity can be used to support discussions of contaminant fate and transport and offsite migration pathways (pathways 3, 7, 8, 10, and 14). In addition, these data may be used to estimate exposure and risk through incidental ingestion during recreational uses of the reservoir or to estimate windborne particulate concentrations for subsequent inhalation exposures.

- **SW-1:** Data characterizing radionuclides in surface water can be used to support discussions of contaminant fate and transport and offsite migration pathways (pathways 4, 9, and 12), in addition to estimating exposure and risk from ingestion or dermal contact with surface water.

- **SW-2:** Same as SW-1.

- **GW-1:** Data characterizing site-specific hydrogeology and potential contaminants in alluvial and confined groundwater systems can be used to support discussions of contaminant fate and transport in addition to estimating exposure and risk from ingestion, inhalation, or dermal contact with groundwater to address pathways 5, 10, and 12.

- **A-1:** Data characterizing the potential for dispersion of contaminated sediments can be used to support discussions of contaminant fate and transport in addition to estimating exposure and risk from inhalation. The pathways these data address are 1, 7, and 14.

- **AQ-6:** Data to determine if fish are accumulating contaminants can be used to estimate exposures and risk from fish ingestion.

Because of the inherent uncertainty of the preliminary assessment, the relative risks of the no-action, remedy implementation, and past remedy scenarios could not be accurately compared. A

- Sample quantitation limits and/or detection limits for nondetects
- Field conditions
- Sample documentation (for example, chain-of-custody and SOPs).

Data lacking any of the above information will be considered for qualitative use in the Human Health Risk Assessment. Data associated with *all* of these attributes will be carried forward for further detailed evaluation and summary.

7.2.2 Data Evaluation

Historical and RFI/RI data will be further evaluated based on EPA's guidelines issued in Guidance for Data Useability in Risk Assessment (EPA, 1990b). The EPA identified the following data usability criteria:

- Assessment of data documentation for completeness
- Assessment of data sources for appropriateness and completeness
- Assessment of analytical methods and detection limits for appropriateness
- Assessment of data validation review
- Assessment of sampling data quality indicators (completeness, comparability, representativeness, precision, and accuracy)
- Assessment of analytical data quality indicators (such as spike recoveries, duplicates, and blanks) for completeness, comparability, representativeness, precision, and accuracy.

health risk as needed for site decisions. It is anticipated that risks resulting from exposure to TICs will not be characterized because of the absence of specific contaminant identity and available toxicological information.

7.2.3 Hazard Identification

The objective of the hazard identification is to identify RFP-related contaminants present at OU 3 in concentrations high enough that may be of concern relative to human health considerations. Previous OU 3 investigations identified Pu-239, Pu-240 and Am-241 within OU 3. In addition to these contaminants, others may be identified based on RFI/RI analytical results. Criteria for performing the hazard identification include, but may not be limited to:

- Frequency of detection
- Environmental media concentrations exceed background concentrations
- Toxicity, mobility, and persistence
- Contaminant can be attributed to RFP activities.

Depending on the number of site-related contaminants identified, one of two things will happen:

1. If only a few site-related contaminants are identified, all of them will be carried through the risk assessment. The contaminants responsible for dominant risks at the site, as well as those contributing lower risk, will be identified .

2. If a large number of site-related contaminants are identified, contaminants of concern (COCs) may be selected and carried through the risk assessment to characterize only those expected to contribute the highest risk. Contaminants of concern will be selected based on the following tasks:

    - Evaluating site historical information; consideration as site-specific, waste-activity related compounds

7.3 EXPOSURE ASSESSMENT

The exposure assessment objective is to determine how exposures to site contaminants could occur, and to estimate the extent of exposure if it occurs. The exposure assessment includes several tasks:

- Characterize the exposure setting relative to contaminant fate and transport and potentially exposed populations
- Identify exposure pathways based on chemical source and release, exposure point and exposure route
- Identify potentially exposed populations and the dynamics of their exposure
- Identify uncertainties associated with the exposure assessment that impact the risk characterization.

Exposure is defined as the contact of an organism with a contaminant or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of a contaminant available at the exchange boundaries (that is, the lungs, intestines, and skin). When contaminants migrate from the site to an exposure point (a location where receptors can come into contact with contaminants), or when a receptor directly contacts contaminated media, exposure can occur.

7.3.1 Conceptual Site Model

The conceptual site models developed for OU 3 (Figures 2-8 and 2-9) will be used to evaluate primary and secondary contaminant sources and releases, and potential receptors and associated exposures. The models help to characterize the exposure setting relative to contaminant fate and transport mechanisms through exposed receptors. These models may be revised, based on RFI/RI data collected for the OU, to incorporate new information.

Established EPA guidance (1989) calls for identifying current and potential future exposure pathways. Current exposure pathways reflect the present site-setting and population activities. The potential future exposure pathways consider a range of exposures based in changes in land use. The EPA (1991) recognizes the difficulty associated with predicting future land use, especially relative to zoning considerations. However, the EPA (1991) suggests developing residential exposure scenarios for most situations. It is anticipated that the OU 3 Human Health Risk Assessment will consider a range of potential future exposure scenarios, including potential future residential scenarios.

7.3.4 Exposure Point Concentrations

By using the data set identified as part of Subsection 7.2.2, exposure point concentrations will be estimated. Some data will be collected at the point of exposure. Other data collected at the source may be used in conjunction with a transport model to estimate expected concentration at some exposure point. Because modeling may add uncertainty, the work plan emphasizes collecting data at exposure points where possible (even though these data provide only a snapshot of conditions in time and space).

Exposure point concentrations will be expressed for a variety of anticipated exposure conditions including the reasonable minimum exposure (RMinE), the expected exposure concentration, and the reasonable maximum exposure (RMaxE). RMinE and RMaxE concentrations are represented by the 95th percent confidence limit on the average or the maximum-reported concentration, whichever is lower. Depending on the quantity of data and their appropriateness for grouping, data distribution will be used to determine the appropriateness of using geometric or arithmetic means to estimate the RMinE and RMaxE and average concentrations.

7.3.5 Contaminant Intake Estimation

Contaminant exposure (or intake) is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg/day). Radionuclide intake is description of physical site attributes that affect exposure and activity patterns. One of the major areas of uncertainty in the exposure assessment is the prediction of human activities that lead to contact with environmental media and exposures to site-related contaminants. This section of the Human Health Risk Assessment will identify and evaluate how site attributes related to environmental sampling and analysis, fate and transport modeling, and exposure parameter estimation and assumptions about them affect uncertainty relative to assessing risk. The exposure assessment uncertainty analysis will evaluate the potential magnitude of over or under estimation, or both, and will provide an indication of the impact, by orders of magnitude, that the uncertainty imparts on the estimation of risk.

7.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to describe the contaminants considered in the Human Health Risk Assessment relative to their potential to cause harm. The toxicity assessment has two general steps. The first determines what adverse health impacts, if any, could result from exposure to a particular contaminant. These are typically classified as carcinogenic and noncarcinogenic health effects. The second step, the dose-response evaluation, quantitatively examines the relationship between the level of exposure and the incidence of adverse health effects.

Toxicity depends on the dose or concentration of the substance (dose-response relationship). Toxicity values are a quantitative expression of the dose-response relationship for a contaminant and take the form of reference doses (RfD) and cancer slope factors, both of which are specific to exposure via different routes.

Two sources of toxicity values are currently available for chemicals and radionuclides. The primary source is the EPA's Integrated Risk Information System (IRIS) data base, which contains up-to-date health risk and regulatory information. IRIS contains only those RfDs and slope factors that have been verified by the U.S. EPA work groups, and is considered by U.S. EPA to be the preferred source of toxicity information for chemicals. Other sources such as ICRP and NCRP will also be consulted.

- Critical toxicity values derivation include, but may not be limited to, the following:

  - Extrapolating toxicity values from high experimental does to low doses for environmental exposures

  - Extrapolating data from tests with experimental animals to humans; extrapolating test data collected over short durations to long-term exposure durations

  - Extrapolating data collected using homogeneous experimental animal populations to humans who individually can vary substantially in their individual dose-response reactions

  - Extrapolating from continuous experimental doses given to animals to intermittent human exposures

  - Extrapolating absorption rates.

The methods used to derive slope factors and reference doses are intended to be conservative in recognizing these types of uncertainties. In addition to the numerical approaches used to incorporate uncertainty in deriving toxicity values, the overall quality of the toxicology data base for a compound is evaluated. This can include consideration of a number of studies, their consistency, the availability of information on multiple species and multiple routes of administration, the demonstration of a clear dose-response relationship, plausible biological mechanisms of action, and especially direct evidence of effects in humans. Such reviews are performed by the EPA in developing toxicity parameter values and result in an overall evaluation of the confidence level in the toxicity values. Not all toxicity values represent the same degree of uncertainty; all are subject to change as new evidence becomes available.

added across exposure routes if conditions for doing so (i.e., biologically plausible and consistent with reasonably expected exposure scenarios) indicate that it is appropriate.

Not all contaminants identified at OU 3 will have toxicity values, thereby limiting the ability to develop quantitative estimates of risk. Where adequate toxicity values cannot be identified, potential risks associated with exposure to those constituents will be dealt with qualitatively.

7.6 UNCERTAINTIES, LIMITATIONS, AND ASSUMPTIONS

The numbers and kinds of uncertainties identified in the Human Health Risk Assessment directly impact the interpretation of estimated risks developed in this section. Quantitative risk estimates derived in risk assessments are conditional estimates that include numerous assumptions about exposures and toxicity. Uncertainty is introduced from a variety of sources including, but not limited to, the following:

- Sampling and analysis
- Exposure estimation
- Exposure population dynamics
- Toxicological data.

The objective of this task will be to evaluate the reliability of the Human Health Baseline Risk Assessment as a scientifically credible instrument upon which to base risk management decisions. An uncertainty analysis will be performed to characterize and quantify, to the extent practicable, the sources and magnitudes of uncertainty in the BRA. Quantitative techniques may include sensitivity analysis, first-order analysis to evaluate the propagation of errors, or numerical methods such as stratified Monte Carlo sampling.

8.0 ENVIRONMENTAL EVALUATION WORK PLAN AND FIELD SAMPLING PLAN

8.1 INTRODUCTION

The objective of this Environmental Evaluation Work Plan (EEWP) is to provide a framework for addressing and quantifying the ecological effects on the biotic environment (plants, animals, and microorganisms) caused by exposure to contaminants from the Rocky Flats Plant (RFP) that have migrated, or are currently migrating to OU 3, the offsite area. This plan describes the major tasks and appropriate sequence of events for performing an environmental evaluation (EE). The EE will be conducted as an integral part of the RFI/RI process to determine if the contaminants of concern from the RFP pose a current or potential risk to the environment, specifically to the biota present in OU 3, in the absence of remedial action. The overall purpose of the EE is to perform a qualitative, and where possible, a quantitative evaluation of actual or potential damage to the environment.

This plan conforms to the requirements of current applicable legislation and agreements; including CERCLA as amended by SARA, the NCP, the IAG, and the Natural Resource Damage Assessment (NRDA) process. Since the EE is conducted as an integral part of the RFI/RI process, the work plan conforms to the National Contingency Plan and is based on CERCLA and RCRA guidance documents for conducting RFI/RI activities. Although a formal NRDA process has not been initiated at Rocky Flats, this work plan is consistent with the NRDLA process to the extent possible to address concerns of the State of Colorado. Guidance for assessing ecological risks was taken primarily from Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (EPA, 1989d) and "Ecological Assessment of Hazardous Waste Sites" (EPA, 1989e). Additional guidance manuals that will be used when appropriate are listed in Table 8-1. The EE approach is designed so that procedures to be performed are appropriate, necessary, and sufficient to adequately characterize the nature and extent of environmental effects under the "no action" scenario, and future conditions arising from this scenario.

The EE or ecological risk assessment at OU 3 will be conducted in conjunction with the ecological assessments being conducted at OUs upgradient of the offsite area, such as the onsite portions of Woman Creek (OU 5) and Walnut Creek (OU 6). Contaminants from these drainages and the onsite OUs adjacent to these creeks, such as OUs 1 and 4, have potentially migrated to and impacted ecosystems within OU 3, because OU 3 is downwind of the RFP and includes the offsite downgradient portions of the Woman Creek and Walnut Creek. Where appropriate, the EE at OU 3 will also be developed in conjunction with human health risk assessments at OU 3 and other applicable OUs. The "Environmental Evaluation Manual" (EPA, 1989d) and the Superfund Exposure Assessment Manual (EPA, 1988c) recognize that the exposure and toxicity assessment processes for ecological and human health risk assessment have much in common, and that ecological and human health assessments are interrelated because humans use natural resources.

Several existing technical documents were reviewed during the preparation of this EEWP. The Final Environmental Impact Statement (EIS) for the RFP (DOE, 1980) and the recent Wetlands Assessment (EG&G, 1990g) provided ecological information. The Past Remedy Report on IHSS 199 (DOE, 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment for IHSS 200-202 (DOE, 1991b) provided excellent summaries of past studies on water, soil, and sediment contamination in the offsite area, and conceptual exposure models for human and biotic receptors in the offsite area. RFI/RI work plans, including environmental evaluation work plans, for several OUs upgradient of OU 3 were reviewed to coordinate planning, maintain consistency in sampling efforts, and ensure compatibility with the environmental evaluations being conducted at the nearby OUs. Other reports, such as the Draft Rocky Flats Surface Water Management Plan (EG&G, 1991e) and the Background Geochemical Characterization Report for 1989 (EG&G, 1990f) provided important information on site characteristics and potential transport mechanisms. New data generated by the implementation of the EE portions of RFI/RI programs at appropriate OUs will be reviewed as they become available.

The EE will provide decision makers with the information required to determine risks to the environment at OU 3 as it presently exists, and an estimate of risks based on future conditions, in

The EE approach, where possible, will establish a cause-and-effect relationship between the site-related contaminants and the actual or potential adverse ecological effects measured during the EE. Three types of data are necessary to establish a cause-and-effect relationship. These are:

- Chemical–Analysis of field samples to establish the presence, concentration, variation, and distribution of the contaminants of concern (completed largely through the RFI/RI site characterization studies)

- Ecological–Ecological surveys to characterize the ecosystem components and establish whether any adverse effects have occurred

- Toxicological–Toxicity testing and ecotoxicological studies to establish the link between an adverse ecological effect and the contaminant of concern.

These three types of data are also required to distinguish the effects of site related contaminants on ecological endpoints from the influences that natural phenomenon may have on the same endpoints.

The principal objective of the EE at OU 3 is to describe and quantify, where possible, the actual or potential ecological effects of RFP related contaminants on the biological receptors within OU 3. To accomplish this, the EE actually has multiple objectives. These include:

- Characterize the ecosystem and biological receptors in OU 3

- Determine the types, forms, and quantities of contaminants of concern within OU 3 (primarily completed by the RFI/RI site characterization)

- Define the extent of contamination

interrelationships are shown in Figure 8-1. The tasks are summarized below. A more detailed description of task activities is presented in Subsection 8.2.

8.1.2.1 Task 1—Initial Planning and Conceptual Model Development

Task 1 is a continuation of the work plan that will focus on the detailed planning for implementing the OU 3 EE, and the coordination of the OU 3 EE activities within the RFI/RI program and health risk assessment at OU 3. The OU 3 EE will also be closely linked with the EE programs for the onsite portions of Woman Creek (OU 5) and Walnut Creek (OU 6), and the other OUs in these drainages. Task 1 will include a review of the scope of work and definition of the study area. Data Quality Objectives (DQOs) will be refined and implemented in Task 1 according to EPA guidance (EPA 1987c), and procedures for monitoring and controlling data quality will be specified.

Criteria for selection of contaminants of concern (COCs), target species, and reference areas (if needed) that have been developed in concert with the sitewide program at the RFP will be reviewed. Conceptual models for conducting the EE and the strategy that will be used to assess risks at OU 3 will be developed during Task 1. This strategy will determine which of the various toxicity-based risk assessment and ecological study techniques would be best suited to assess risks at this OU, based on the known characteristics of the site and the conceptual models.

8.1.2.2 Task 2—Data Evaluation and Preliminary Risk Assessment

Task 2 will include review, evaluation, and summary of available chemical and ecological data and identification of data gaps. This information will be compiled into a comprehensive data source. The study site will be characterized using available information on biotic resources and abiotic factors influencing the fate and transport of contaminants. Also, the contaminants of concern, target species, and reference sites will be refined based on the additional information and the criteria developed in Task 1.

concurrently so that the results become the main source of information for conducting a final planning step (Task 8).

8.1.2.4 Task 4—Toxicity Assessment

Task 4 will entail compilation of scientific literature to prepare toxicity profiles for the COCs. The scientific literature will also be reviewed to identify the specific concentrations of COCs that are known or expected to have toxic effects. Task 4 will include compiling contaminant specific ARARs such as ambient water quality criteria and other concentration levels or doses that reflect toxicity. This will be used subsequently in Task 6 to characterize risks. Finally, during Task 4 initial toxicity test will be conducted and evaluated to determine if media (surface water and sediments) existing within OU 3 is toxic to organisms. These initial tests will follow standard EPA protocol using fathead minnows and *Ceriodaphnia*.

8.1.2.5 Task 5—Exposure Assessment

In this task, site-specific pathway model(s) will be developed based on the conceptual site models developed in Tasks 1 and 2. Then, these pathway models will be verified based on the ecological field investigations conducted in Task 3. These source-receptor pathway models will be used to evaluate the transport of OU 3 contaminants to target taxa, the biological receptors. The pathway models are based on a conceptual pathways approach (Fordham and Reagan 1991) which describes the actual or potential contaminant releases, and an initial determination of the movement and distribution of contaminants at the site. The likely interactions among ecosystem components, and the expected exposures and/or chemical intake will be estimated. Task 5 will utilized the scientific literature and data collected during the RFI/RI site characterization to estimate or measure concentrations of COCs at expected exposure points. Existing information and other RFI/RI data will also be used to identify OU 3 specific factors that may influence the migration, bioavailability, or toxicity of the COCs.

planned where acceptance criteria for demonstrating injury to a biological resource will be satisfied in accordance with regulations under the NRDA (43 CFR Subtitle 1, Section 11.62[f]).

8.1.2.9 Task 9—Ecotoxicological Investigations

Task 9 will include collection of samples for tissue analysis and any additional ecotoxicological field investigations according to the revised FSP developed in Task 8. Samples collected during the Task 3 field studies will be used when possible, but new samples will be collected if necessary. Task 9 will include tissue analysis studies to correlate the concentrations of contaminants in environmental media with concentrations in receptors. Additional field investigations may be conducted to collect additional toxicity and ecological endpoint data for comparative studies and to validate exposure or dose models.

8.1.2.10 Task 10—Risk Characterization and Report

Results from Tasks 8 and 9 will be used to assess the effects of site-related contaminants on biota at OU 3, and to evaluate population or ecosystem effects in a final contamination risk assessment. Information on site characteristics and contaminants, characterization of effects, remediation criteria, conclusions, uncertainty analysis, and limitations of the assessment will be summarized in an EE report. An initial draft report will be written which includes remediation criteria, and the final report will be prepared based on quality control and technical reviews of the draft report.

Each of the preceding tasks is described in further detail in Subsection 8.2. The field sampling plan presented in Subsection 8.3 addresses both the Task 3 ecological investigation and the Task 9, ecotoxicological field investigations.

8.1.3 OU 3 Contamination

A number of chemicals are suspected to be present in the OU 3 soils, surface water, and sediment that may be related to past or current releases from the RFP. Preliminary reviews of available data

1950s and 1960s. Most prior studies of OU 3 and surrounding areas have focused on plutonium and other radionuclides, so very few data exists for other contaminants.

Additional data on site-related contaminants will be collected during the RFI/RI (see Section 6.0) and will be used in assessing potential or actual risks to OU 3 biota. Additional soil sampling will also be conducted in concert with vegetation sampling during this EE. And, as described in Tasks 1 and 2, additional effort will be made early in this EE to refine the identification of chemicals of concern for OU 3.

Depending on physical properties, contaminants may become differentially distributed among environmental media or among components within a medium. The result may be differential exposure of species or populations to the contaminant. The factors affecting distribution in environmental media include:

- Persistence–the resistance to degradation by abiotic or biotic processes

- Volatility–the tendency to volatilize, thus reducing soil or water concentration

- Mobility–the degree to which a chemical tends to migrate within or between environmental media, thus placing further resources at risk; or the chemical is strongly absorbed or adsorbed on soil or sediment particles

- Solubility–the solubility in aqueous solutions, which may affect mobility in surface and groundwater

- Differential Accumulation–the tendency to segregate into different environmental media or components of a single medium.

These factors were considered when developing the target analyte list for analyses of specific organisms, tissues, or abiotic media in Subsection 8.3.

The grasslands are concentrated on the areas just east of the RFP along Indiana Street. They are either presently grazed or have been heavily grazed in the recent past, so that the species composition and condition are affected. Low growing grasses are common as are introduced grasses and weedy species. Recent intensive activity by a large prairie dog population have reduced many grassland habitats to a weedy/forb stage. The remediation acreage of 250 acres within OU 3 has not been effectively revegetated (see Subsection 2.1.2). Small wetlands along drainages and the edges of reservoirs are a short or tall marsh habitat type, but may be seasonally dry due to water control and fluctuations. The riparian habitats consist of narrow zones of shrubland in the upper drainages such as Woman Creek and the ditch leading to Mower Reservoir, or of single rows of cottonwood trees along the lower broader drainages.

Animal species that may be receptors of contamination include the fossorial rodents (prairie dog) or the ground dwelling rodents such as the microtines. Larger animals such as deer and raptors use the study area but are wide ranging and not confined to OU 3.

8.1.4.2 Aquatic Habitats and Receptors

The aquatic resources within OU 3 include the reservoirs used for municipal water supply and/or irrigation (Great Wester Reservoir, Mower Reservoir, and Standley Lake), three ephemeral creeks that drain the RFP and the area just south of the RFP (Walnut, Woman, and Upper Big Dry Creek), small usually dry drainageways tributary to the creeks, and irrigation ditches. The Upper Church Ditch conveys water from Clear Creek to Great Western Reservoir (Broomfield's water supply), and in recent years represents the total water source for the reservoir except for localized stormwater runoff. Water that formerly entered Great Western Reservoir via Walnut Creek is now retained within RFP retention basins or diverted around Great Western via the Broomfield Diversion Ditch. Two irrigation ditches, the Croke and Highline Canals, supply around 90 percent of the water going into Standley Lake. This reservoir is the water supply for the Cities of Westminster, Northglenn, Thornton, and Federal Heights.

operations at RFP has limited flows in Woman Creek even further and essentially halted natural flows in Walnut Creek. As a result, Walnut and Woman Creek within OU 3 probably do not support any fish populations. The periphyton and benthic macroinvertebrate populations, if present, are strongly influenced by the seasonal water supply. Upper Big Dry Creek and Smart Ditch are relatively small watersheds south of the RFP (Figure 2-1) and drain primarily agricultural land. They are ephemeral with no natural flows in late summer and fall. There is essentially no information on the biotic resources of Upper Big Dry Creek and Smart Ditch.

8.1.4.3 Threatened and Endangered Species and Special Habitats

OU 3 is predominately former agricultural land containing three large reservoirs, a few farms, and a few residential developments. Dense highly developed residential areas are located on the eastern and southern edges of OU 3. Information on threatened and endangered species, and plant species of state concern, were obtained from RFP files, the Colorado Division of Wildlife, and the Colorado Natural Areas Program.

Threatened or endangered animals that potentially could occur in the OU 3 area, at least on a season basis, include the bald eagle, Preble's meadow jumping mouse, peregrine falcon, and the black-footed ferret (EG&G, 1991g; DOE, 1980). Bald eagles occur seasonally in the OU 3 area, and lately have been regular visitors during the winter around Standley Lake. Bald eagles are regular seasonal visitors or residents at Barr Lake and the Rocky Mountain Arsenal 25 to 30 miles east of the RFP. Peregrine falcons may occur as rare visitors to the area, and a nesting pair was reported in the front range foothills about 10 km northwest of the RFP in 1991. Black-footed ferrets are probably extinct in Colorado, but the relatively large colonies of prairie dogs in the OU 3 area provide suitable habitat and food for this endangered species. Other threatened or endangered animal species or candidate species may be rare visitors in the area, such as whooping cranes and mountain plovers, but the OU 3 area is not their preferred habitat.

Four plant species that are listed by the Colorado Natural Areas program are potentially present in the OU 3 area. Ute lady's tresses, *Spiranthes diluvialis*, is a federally-listed threatened species that

8.2.1 Task 1—Initial Planning and Conceptual Model Development

This task includes the initial coordination effort to coordinate the implementation of the EE at OU 3 with the RFI/RI, human health risk assessments, and EEs at other appropriate OUs. The study area and scope of work will be defined, then the data quality objectives will be identified. A major component of Task 1 was the development of a conceptual site model. Six subtasks are planned.

8.2.1.1 Subtask 1.1—Coordinate with RFI/RI Program and Other OUs

The EE work at OU 3 will be coordinated closely with the RFI/RI sampling activities and human health risk assessment process at OU 3. The intent of this subtask is to coordinate the sampling of the abiotic media (soil or water) at the same location and time as the biotic sampling where appropriate, and avoid duplication and inconsistencies when developing fate and transport, exposure pathway, and toxicity profile information. The site characterization for abiotic media is important to the EE.

The EE at OU 3 will be coordinated with the EE programs at other OUs, especially OU 2, OU 5, and OU 6. These three OUs are the onsite OUs east of Indiana Street that will address ecosystems similar to, and upgradient of, OU 3. Information developed by the onsite OUs will be acquired as it becomes available, and the selection of COCs, target species, and reference areas will be coordinated among these OUs. The conceptual exposure models developed for OU 3 will be compared to the EE approach used at the onsite OUs to maintain consistency in the methodology for assessing risks.

8.2.1.2 Subtask 1.2—Define Study Area and Scope of Work

The boundaries of the OU 3 study area and the plans for seasonal sampling was determined based on the initial site visit information and discussions with DOE, EPA, and CDH. The detailed scope of work and boundaries will be described and reviewed with the same agencies. The scope of work will identify the ecosystems, communities, or populations that will be sampled in the field; propose

8.2.1.4 Subtask 1.4—Develop Selection Criteria

Implementation of the EE will require selecting contaminants of concern, target species or communities, and reference areas. These will be selected using a set of criteria and procedures that are applied sitewide. The selection criteria and processes have been initially developed and are summarized below. Furthermore, the contaminants of concern for the OU 3 EE have been tentatively identified and are presented in Section 8.2.2., Subtask 2.4. This subtasks will review the most recent selection criteria and guidelines and coordinate final criteria selection with other OUs. The final criteria will then be used in Subtasks 2.4 to conduct the actual selection of COCs, target species, and reference areas.

The criteria for selecting COCs were developed in concert with EG&G (1991h) and have been reviewed by EPA. The criteria are arranged in three general categories: documentation of occurrence of the chemical in environmental media, ecotoxicity of the chemical, and extent of contamination at the site. These criteria are discussed in more detail below.

1. Occurrence—the known or suspected occurrence of a chemical in environmental media will be ascertained from:

   - Existing data from abiotic media (soil, water, air), or from biota
   - Waste stream identification and disposal practices
   - Process analyses to identify potentially hazardous substances used in large quantities
   - Historical accounts of use or accidental release

   The resulting list of chemicals will then be evaluated for ecotoxicity and the extent of contamination at the site.

In addition, a chemical may be included as a COC if:

- It is reported in greater than 5 percent of the samples analyzed for a given area; and at least one of the following:
  - It is widely distributed; or
  - It occurs in ecologically sensitive areas such as wetlands or seeps; or
  - It occurs in localized areas of high concentration ("hot spots").

Chemicals that satisfy the above criteria for occurrence, toxicity, and extent were partially identified and are described in Subtask 2.3.

A relatively small number of target species or target taxa (for example, the benthic macroinvertebrates in a stream) will be selected to assess the effects of site-related contaminants on biological receptors and to assess bioaccumulation of contaminants. The target species will be representative of the organisms at OU 3 and will be species that are likely to exhibit the effects of the RFP contaminants. The selection criteria will follow guidelines recently proposed by EG&G (1991j), and separate criteria will be used to select target species for destructive sampling (e.g., tissue analysis) and nondestructive sampling (e.g., population surveys). The criteria for target species may include the following:

- Must potentially exhibit the effects of the COC
- Have a home range relative to the area of contamination
- Be economically important
- Represent an important component in the structure and function of the ecosystem

- Exposure routes
- Relative susceptibility of receptors
- Types of impacts.

Additional models may be developed to evaluate specific food chains or food webs, or assess bioconcentration or biomagnification processes in terrestrial or aquatic ecosystems. Also, after additional information is acquired during the literature review in Task 2, the conceptual models will be reviewed and modified as appropriate.

Subsections 2.5.1 and 2.5.2 discuss the conceptual models for surface soils and the reservoirs respectively. These sections summarize the nature of the radionuclide and nonradioactive contaminants at OU 3 as presently known; describe the contaminant characteristics, release mechanisms, and fate and transport issues; and present the most plausible exposure routes to human and biological receptors.

8.2.1.6 Subtask 1.6—Develop Risk Assessment Strategy

There are several methods or techniques for assessing risks to biological receptors at hazardous waste sites. Some of these are primarily qualitative, others are quantitative. To reduce uncertainty in ecological assessments, two or more techniques can be used to asses the influence of a given contaminant on the same target species, and if the results from the different techniques support the same conclusion the degree of uncertainty decreases. This approach of using two or more techniques to assess the effects on one target taxa is referred to as the "weight of evidence" approach in this work plan.

This subtask will involve reviewing several assessment techniques and recommending the most appropriate mix of techniques for OU 3. This review process will incorporate information gained from the preliminary conceptual model and consider the data quality objectives developed in Subtask 1.3. Furthermore, as more information is acquired during Task 2, the risk assessment strategy will be reviewed and modified as appropriate. Five techniques that may be used to assess risks at OU 3 are briefly described below.

Method 1—Comparing Exposure Point Concentrations. This method involves comparing the concentrations of a contaminant at known exposure points to published criteria, or regulatory standards, or to concentrations or doses known to cause adverse or toxic effects. This comparison-to-criteria approach, employing criteria and toxicity values that have been established from the toxicological literature, is an important component in the process of characterizing risks, and is frequently the technique used to make some initial assessment at the site.

Method 2—Evaluating Toxicity Test Data. A second risk analysis method involves comparing or extrapolating data from laboratory toxicity tests to exposure of natural onsite populations. For example, concentrations of a contaminant in water at an OU 3 sampling station might be compared to laboratory tests that determined the lowest observable adverse effect level of that contaminant on fathead minnows. Or, the concentrations of a contaminant in soil and vegetation at OU 3 might be compared to tests that studied lethal doses for laboratory mice exposed to soil and vegetation containing that contaminant. Appropriate correction or safety factors may be applied to incorporate variability among species and life stages, and account for differences between conditions in the laboratory and in the natural environment. The correction or safety factors could be determined following procedures such as those described by EPA (EPA, 1985) and Barnthouse (Barnthouse, et al., 1986). This method will indicate what concentrations of a contaminant might be considered safe. A logical refinement of this method would be to conduct toxicity tests on native species using water or soil from the OU 3 area, and simulating environmental conditions as much as practical.

Method 3—Comparing Ecological Endpoints or Biomarkers. A third method is based on comparing onsite populations in known or expected contaminated areas to similar populations at reference (upgradient uncontaminated) areas. Population parameters (such as growth, reproduction, and mortality rates) or community parameters (such as species diversity, standing crop, and productivity) will be used to assess the differences between impacted and nonimpacted areas. Biomarkers are specific effects on target organisms that can be assessed in the field for target species or populations.

Method 4—Comparing Estimated Intake Rates. This method is essentially a dose-response approach that uses acceptable chemical intake rates from the literature. If the ratio of the estimated chemical intake to an acceptable chemical intake exceeds 1.0 (unity) for the defined exposure scenario, there is an indication that the exposed species may be subject to an adverse impact. If the ratio is below unity, it is generally assumed that no adverse impact will occur. This method is similar to the approach used for human health risk assessments.

Method 5—Evaluating Bioaccumulation Levels. In the fifth method, exposed populations will be examined for contaminant-specific concentrations to determine if the contaminant is accumulating in the individual organisms that make up the population. The bioconcentration factors will be compared to published sources for possible effects or tissue concentrations that may adversely affect the organisms.

8.2.2 Task 2—Data Evaluation and Preliminary Risk Assessment

The principal subtasks in Task 2 include additional review and evaluation of existing literature for a data compilation, characterizing OU 3 based on existing data/literature; identifying data gaps; identifying COCs, target species, and reference areas; preparing an initial risk assessment; and modifying the risk assessment strategy and field sampling plan if warranted.

8.2.2.1 Subtask 2.1—Review, Evaluate, and Summarize Existing Data

The initial and principal activity in Task 2 will be acquiring additional existing literature on OU 3, on similar ecosystems, and on the contaminants of concern and evaluating that information. Data from ongoing monitoring programs and existing literature available from DOE and EG&G (the operating contractor at the RFP) will be acquired, along with literature from state and federal agencies and universities. Task 2 will focus on accumulating, analyzing, and summarizing existing literature in three major areas:

- Biota present at OU 3, population and community characteristics, and food web interrelationships

- Types, concentrations, and distribution of contaminants in environmental media; including soil, surface water, sediments, and biota

- Contaminant release mechanisms, fate and transport of COCs, toxicity of COCs,and potential exposure pathways.

The existing physical and chemical information for OU 3 site characterization, as well as the extent and distribution of contaminants in the immediate vicinity, are evaluated and summarized in two recent DOE reports: the Final Past Remedy Report (DOE, 1991a) and the Historical Information Summary and Preliminary Health Risks Assessment (DOE, 1991b). These reports and their appendices were extensively used in this preparation of this EE. These two reports summarize several previous studies of the offsite area east of RFP, and include a qualitative human health risk assessment for the four IHSS's within OU 3. The prior investigations specifically targeted offsite contamination as a result of past releases from RFP; primarily plutonium and its degradation product, americium. As documented in the two DOE reports, data on other types of contaminants are limited, and the data from the earlier reports generally do not meet current quality control standards to support a rigorous quantitative health risk assessment. The two DOE documents do not discuss environmental risks, and have not presented or summarized the information available on terrestrial and aquatic ecosystems.

A number of other reports and data resources will be reviewed for general and site-specific information for the ecological risk assessment. These include reports by federal, state, and county agencies; studies by local universities that are currently being or have been conducted for DOE; and ongoing programs at Standley Lake such as the limnological study by the U.S. Geological

Survey (USGS) and the Standley Lake Protection Project by the City of Westminster. The collection and review of the existing data base on terrestrial and aquatic ecosystems, wetlands and flood plains, threatened and endangered species, soils, and other topics will in itself be a significant task. It will guide how each of the subsequent tasks are to be conducted. The information and data will be systematically evaluated for usability and compiled into a data base system to be set up as a portion of Task 2.

Site-specific information and the scientific literature will be reviewed and analyzed to provide a comprehensive data source for the EE. The data evaluation and analysis task will review the existing data base to assess the following:

- The identification of possible additional COCs
- Site-specific characteristics (climatology, surface water, groundwater, soils, geology, hydrology, geochemistry, and terrestrial and aquatic ecosystems) related to the release, transport, and uptake of contaminants
- The adequacy of data and additional data needs
- The identity of the plants and animals that make up the living component of the ecosystems
- The mechanisms that result in the exposure to contaminants and uptake by biota
- The assessment of toxicity or other effects of the contaminants on the living organisms at OU 3
- The estimated potential or actual adverse effects on the plants and animals that result from exposure to site contaminants.

The following sources will be used to acquire general information and site specific data; this information will be incorporated into the data base established for OU 3:

- Project and data files maintained by EG&G, including the background (geochemical) characterization studies and the annual environmental surveillance program reports including offsite areas

- Studies on radionuclide uptake, retention, and effects on plant and animal populations conducted by the University of Colorado and Colorado State University on the RFP and on OU 3

- The Rocky Flats Environmental Impact Statement data base

- Sampling results from ongoing RFI/RI programs at OUs 1, 2, 5, and 6, including ecological investigations similar to those proposed here for OU 3

- The scientific literature, including ecological and risk assessment reports at the following DOE facilities: Oak Ridge National Laboratory, Los Alamos National Laboratory, Brookhaven National Laboratory, and the Nevada Test Site.

This data review/evaluation task will culminate in a working document that will summarize the cumulative inventories of flora and fauna in the OU 3 area, present preliminary exposure pathways for the biological receptors, and identify sensitive populations. The existing files on threatened and endangered species will be summarized and contacts will be made with the U.S. Fish and Wildlife Service, Colorado Division of Wildlife and the Natural Areas Inventory Program to update files if needed. The working document will be used to communicate to DOE the principal data gaps that exist relative to the ecological risk assessment.

8.2.2.2 Subtask 2.2–Develop Initial Ecological Site Characterization

Environmental and ecological resources at OU 3 will be characterized on the basis of reviews of existing literature and reports, including results from the RFI/RI and other OU RFI/RIs. This information will be compiled and used in the preliminary risk assessment (Subtask 2.4) for pathway and exposure analysis. The description of the site will be presented in terms of the following resource areas:

- Soils and sediments
- Surface and groundwater
- Meteorology/air quality
- Terrestrial ecosystems
- Aquatic ecosystems.

The purpose of the site characterization is to describe resource conditions as they currently exist. The narrative with supporting data will include descriptions of each resource. There will be appropriate tables and figures to clearly and concisely depict site conditions, particularly as they influence contaminant fate and transport and the likelihood that the contaminants may adversely affect biological receptors.

Terrestrial and aquatic species in the RFP area have been described by several researchers: Quick, 1964; Weber et al., 1974; Winsor, 1975; Clark, 1977; Clark et al., 1980; CDOW, 1981; and CDOW, 1982a, 1982b. Many of these reports are summarized in the Final EIS (U.S. DOE, 1980). In addition, terrestrial and aquatic radioecology studies conducted by Colorado State University and DOE (Johnson et al., 1974; Little, 1976; Hiatt, 1977; Paine, 1980; Rockwell International, 1986), along with annual monitoring programs at RFP, have provided information on plants and animals in the area and their relative distribution. More recent data on species distribution and abundance will be obtained from the baseline vegetation and wildlife studies and EEs underway at OUs 1, 2, and 5.

8.2.2.3 Subtask 2.3 Identify COCs, Target Species, and Reference Areas

This subtask represents a continuation of Subtask 1.4. In this subtask, additional information on OU 3 contaminants and biota is acquired, and there is an initial identification of COCs and target species using selection criteria developed in Subtask 1.4. The final selection of COCs, target species, and reference areas will be made during the implementation of this task. A summary of the potential contaminants for terrestrial and aquatic ecosystems are presented in Tables 8-2 through 8-5. These tables are preliminary lists since the present information is not completed or verified, and the tables were constructed from readily available information.

Table 8-6 illustrates how the characteristics of the potential COCs were compared to the selection criteria, to generate the preliminary list of COCs. This table is incomplete and was included in the work plan as an example of the format to be used during the EE implementation. These criteria include the physical properties of the contaminant (such as solubility in water and affinity for soils), resistance to degradation (both chemical and biological), and tendency to bioaccumulate. Based on this table and the currently available information on OU 3, the criteria presented in Subtask 1.4 were applied to expected site contaminants, providing a preliminary list of COCs for terrestrial and aquatic sampling (Table 8-7). During implementation of Subtask 2.3, this preliminary list will be reviewed and revised based on the additional information acquired during Tasks 1 and 2. The COCs will also be selected based on the regulatory status of the potential contaminants, and on the nature and extend of contamination. The final list of COCs will probably be limited to metals and radionuclides in aquatic ecosystems, and radionuclides in terrestrial ecosystems.

A preliminary list of target species was also developed based on the initial site visit, and using the existing information and criteria proposed by EG&G, and is presented in Table 8-8. The target taxa were selected using information on the common plants and animals that occur within the OU 3 study area. Selection criteria included; the species importance in the structure and function of the ecosystem, their economic importance or value as a sport species or aesthetic resource, their availability, and their ability to accumulate one or more of the COCs. Separate lists of target species will be developed during the EE for species that will be subject to destructive and nondestructive

TABLE 8-2

SUMMARY OF POTENTIAL METAL CONTAMINATION OF OU 3 FOR AQUATICS ECOSYSTEMS

Parameters	Maximum Value Reported (ug/l)	Location*	Site-wide Background (ug/l)	Federal Standards: AWQC for Protection for Aquatic Life (ug/l) Acute	Federal Standards: AWQC Chronic	Federal Standards: MCL (ug/l)	State Standards: Biological Parameters for Aquatic Life (ug/l) Acute	State Standards: Biological Parameters Chronic	State Standards: Stream Segment Standard (ug/l) Acute	State Standards: Stream Segment Chronic
TAL METALS LIST										
Aluminum	2140	surface water	60,423			50	950	150		
Antimony										
Arsenic	2.1	surface water	1,030	360**	190**	0.002			50	
Barium	99.1	surface water				1000				
Beryllium	90	surface water	11	130	5.3	0.0068				
Cadmium						5				
Calcium										
Cesium										
Chromium			275	1700**	210**	50	TVS**	TVS**		
Cobalt			489							
Copper	36.3	surface water	607	18	12	12	TVS	TVS	TVS	TVS
Cyanide	6	surface water								
Iron	1410	surface water	87,147		1,000	300		1,000		300
Lead	14	surface water	516	82	3.2	50	TVS	TVS	TVS	TVS
Lithium	33	surface water								
Magnesium										
Manganese	279	surface water	1,965			50				50
Mercury	0.3	surface water	1.4	2.4	0.012	0.2			0.01	
Molybdemum	300	surface water								
Nickel			646	1,400	160	200	TVS	TVS	TVS	TVS
Potassium										
Selenium	12	surface water	25	260	36	10	135	17	10	
Silver	20	surface water				50				
Sodium										
Strontium	520	surface water								
Tin	45	surface water								
Thallium										
Vanadium	313	surface water								
Zinc	300	surface water	376	120	110	100	TVS	TVS	TVS	TVS

* These values are for sites along the east side of Indiana Street (see Table 6-4, Section 6.2). A table similar to this for sediment concentrations should be done if background levels and federal and state standards can be determined.
** These values are for trivalent arsenic and trivalent chromium.
TVS = Table Value Standards (see Table 3.3, Section 3.2)

TABLE 8-3

SUMMARY OF POTENTIAL RADIONUCLIDE CONTAMINATION OF OU 3 FOR TERRESTRIAL ECOSYSTEMS

Analyte	Maxium Value Reported (pCi/g)	Location*	Site-wide Background of Soil (pCi/g)	Federal** Standards	State** Standards
Americium 241 Plutonium 239 + 240 Uranium 233 + 234 Uranium 235 Uranium 238	6.47	soil			

* Plutonium values from remedial lands east of Indiana Street (Tables 2-4 through 2-6, Section 2.1.2)
** Standards for exposure to terrestrial media for soils and air contaminant concentrations will be developed similar to aquatic standards, if possible.

TABLE 8-4

SUMMARY OF POTENTIAL RADIONUCLIDE CONTAMINATION OF OU 3 FOR AQUATIC ECOSYSTEMS

Analyte	Maximum Value Reported (pCi/l)	Location*	Site-wide Background of Surface Water (pCi/l)	Federal Standards (will need be determined)	State Stream Classification Standards	
					Basin Table D Radionuclide Standards	Table 2- Radionuclide Standard for S. Walnut Creek
Gross Alpha**	17.5	surface water	117.43			11 pCi/l
Gross Beta**	12.881	surface water	163.20			9 pCi/l
Americium 241	0.02	surface water				
Plutonium 239 + 240	0.0112	surface water	1.46		15 pCi/l	0.05 pCi/l
Tritium	230	surface water	2,022.45		20,000 pCi/l	500 pCi/l
Uranium-233 + 234	3.93	surface water	1.10			10 pCi/l
Uranium 235	0.33	surface water				
Uranium 238	3.269	surface water	0.19			10 pCi/l

* These values are for sites along the east side of Indiana Street (see Table 6-4, Section 6.2). A table similar to this for sediment should be done if background levels and federal and state standards can be determined.

** Dissolved and suspended values added together.

TABLE 8-5

SUMMARY OF POTENTIAL ORGANIC CONTAMINATION OF OU 3 IN AQUATIC ECOSYSTEMS OF MOWER RESERVOIR AND ITS DIVERSION DITCH

Analyte	Maximum Value Reported (ug/l)	Location*	Quantitation Limits		Federal Standards			
					CWA AWQC for Protection of Aquatic Life (mg/l)		CWA Water Quality Criteria for Protection of Human Health (ug/l)	
			Water (ug/l)	Sediment (ug/kg)	Acute	Chronic	Water and Fish	Fish Consumption
VOLATILE ORGANICS								
Chloromethane			10	10				
Bromomethane			10	10				
Vinyl chloride			10	10				
Chloroethane			10	10				
Methylene Chloride	14	surface water	5	5				
Acetone	19	surface water	10	10				
Carbon disulfide	5	surface water	5	5				
1,1-Dichloroethene			5	5				
1,1-Dichloroethane			5	5				
total 1,2-Dichloroethene			5	5				
Chloroform			5	5				
1,2-Dichloroethane	4	surface water	5	5				
2-Butanone	27	surface water	10	10				
1,1,1-trichlorethane	4	surface water	5	5				
Carbon tetrachloride			5	5				
Vinyl acetate	3	surface water	10	10				
Bromodichloromethane			5	5				
1,1,2,2-Trichloroethane			5	5				
1,2-Dichloropropane			5	5				
trans-1,3-Dichloropropene			5	5				
Trichloroethene	2	surface water	5	5				
Dibromochloromethane			5	5				
1,1,2-Trichloroethane			5	5				
Benzene	1	surface water	5	5				
cis-1,3-Dichloropropene			5	5				
Bromoform	2	surface water	5	5				

TABLE 8-5

SUMMARY OF POTENTIAL ORGANIC CONTAMINATION OF OU 3 IN AQUATIC ECOSYSTEMS OF MOWER RESERVOIR AND ITS DIVERSION DITCH (Concluded)

Analyte	Maximum Value Reported (ug/l)	Location*	Quantitation Limits		Federal Standards			
					CWA AWQC for Protection of Aquatic Life (mg/l)		CWA Water Quality Criteria for Protection of Human Health (ug/l)	
			Water (ug/l)	Sediment (ug/kg)	Acute	Chronic	Water and Fish	Fish Consumption
2-Hexanone	7	surface water	10	10				
4-Methyl-2-pentanone			10	10				
Tetrachloroethene	4	surface water	5	5				
Toluene	6	surface water	5	5				
Chlorobenzene	1	surface water	5	5				
Ethyl benzene	1	surface water	5	5				
Styrene			5	5				
Total Xylenes	6	surface water	5	5				
PESTICIDES/PCBs								
Altrazine	2	surface water	10	670				
Simazine	6	surface water	10	670				

* This is for all locations along the east side of Indiana Street (Table 6-4, Section 6.2) and will need to be modified for samples specifically from Mower Reservoir and its diversion ditch. A table similar to this for sediment concentrations should be done if background levels and federal and state standards can be determined.

TABLE 8-6

OU CONTAMINANTS OF CONCERN SELECTION MATRIX

Analyte	*Criterion 1 - Occurrence				**Criterion 2 - Ecotoxicity			**Criterion 3 - Extent of Contamination							Summary of Criteria			COC
	a	or b	or c	or d	a	or b	or c	a	and b	or c	OR d	and e	or f	or g	1	2	3	
TAL METALS																		
Aluminum	X				X	X									X	X		
Antimony																		
Arsenic	X				X		X								X	X		
Barium	X														X			
Beryllium	X				X										X	X		
Cadmium	X														X			
Calcium																		
Cesium																		
Chromium	X				X										X	X		X
Cobalt	X														X			
Copper	X				X		X								X	X		
Cyanide																		
Iron	X														X			
Lead	X						X								X	X		X
Lithium																		
Magnesium																		
Manganese	X														X			
Mercury	X				X		X								X	X		X
Molybdenum																		
Nickel	X				X										X	X		X
Potassium																		
Selenium	X				X		X								X	X		
Silver	X														X			
Sodium																		
Strontium																		
Tin																		
Thallium																		
Vanadium	X														X			

TABLE 8-6

OU CONTAMINANTS OF CONCERN SELECTION MATRIX
(Continued)

Analyte	*Criterion 1 - Occurrence							**Criterion 2 - Ecotoxicity					**Criterion 3 - Extent of Contamination													Summary of Criteria			COC
	a	or	b	or	c	or	d	a	or	b	or	c	a	and	b	or	c	OR	d	and	e	or	f	or	g	1	2	3	
Zinc	X							X																		X	X		
PESTICIDES/PCBs																													
Altrazine	X																									X			
Simazine	X																									X			
VOLATILE ORGANICS																													
Chloromethane																													
Bromomethane																													
Vinyl chloride																													
Chloroethane																													
Methylene Chloride	X																									X			
Acetone	X																									X			
Carbon disulfide	X																									X			
1,1-Dichloroethene																													
1,1-Dichloroethane																													
total 1,2-Dichloroethene																													
Chloroform																													
1,2-Dichloroethane	X																									X			
2-Butanone	X																									X			
1,1,1-trichlorethane	X																									X			
Carbon tetrachloride																													
Vinyl acetate	X																									X			
Bromodichloromethane																													
1,1,2,2-Trichloroethane																													
1,2-Dichloropropane																													
trans-1,3-Dichloropropene																													
Trichloroethene	X																									X			
Dibromochloromethane																													
1,1,2-Trichloroethane																													
Benzene	X																									X			

-TABLE 8-6

OU CONTAMINANTS OF CONCERN SELECTION MATRIX (Concluded)

Analyte	*Criterion 1 - Occurrence							**Criterion 2 - Ecotoxicity					**Criterion 3 - Extent of Contamination													Summary of Criteria			COC
	a	or	b	or	c	or	d	a	or	b	or	c	a	and	b	or	c	OR	d	and	e	or	f	or	g	1	2	3	
cis-1,3-Dichloropropene																													
Bromoform																													
2-Hexanone																													
4-Methyl-2-pentanone																													
Tetrachloroethene	X																									X			
Toluene	X																									X			
Chlorobenzene	X																									X			
Ethyl benzene	X																									X			
Styrene																													
Total Xylenes	X																									X			
RADIONUCLIDES																													
Gross Alpha	X									X																X	X		
Gross Beta	X									X																X	X		
Americium 241																													X
Plutonium 239 + 240	X									X		X														X	X		X
Tritium	X																									X			
Uranium 233 + 234																													
Uranium 235																													
Uranium 238																													X

*1 a. Existing data
b. Waste stream characterization
c. Process analysis
d. Historical data

**2 a. Acute or chronic toxicity
b. Sublethal toxicity
c. Bioaccumulates

***3 a. Above background concentration
b. Above pertinent ARAR
c. Above risk-based level (level not yet determined)
d. Occurs in >5% of samples (not reviewed)
e. Widely distributed (not reviewed)
f. Occurs in ecologically sensitive area (not reviewed)
g. Occurs in "hot spots" (not reviewed)

TABLE 8-7

PRELIMINARY LIST OF CONTAMINANTS OF CONCERN FOR OU 3 ENVIRONMENTAL EVALUATION

Aquatic

Uranium
Plutonium
Americium

Chromium
Beryllium
Nickel
Lead
Mercury

Terrestrial

Plutonium
Americium

Uranium

TABLE 8-8

POTENTIAL TARGET SPECIES AND HABITATS FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT RFP OPERABLE UNIT NO. 3

Community/Population	Species/Organism
Periphyton	• Diatoms • Green algae • Blue-green algae
Benthic Macroinvertebrates	• Mayflies • Caddis flies • Chironomids
Fish	• Sun fish • Minnows • Bullhead • Walleye • Smallmouth bass • Channel catfish
Herbivores	• Deer mice • Northern pocket gopher • Microtines • Prairie dog
Carnivores	• Long-tailed weasel • Red fox • Coyote
Grasses	• Western wheatgrass • Blue grama
Shrubs/Forbs	• Yucca • Snowberry • Sumac
Trees	• Cottonwood
Wetlands	• Willows • Cattails • Sedges • Rushes

sampling, and the capability of the natural populations to compensate to sampling pressure (i.e., not be affected by sampling) will be considered. This subtask will produce the list of target species that will be addressed during Task 3, Ecological Investigations, and Tasks 4-7, the Toxicity-Based Risk Assessment Program. Based on the model (Subtask 1.5), a modified list of species will be compiled using toxicological information (toxicity assessment) to determine which species or species groups might be most affected by, or most sensitive to, the COCs.

Reference areas may be used to assess impacts at OU 3. In order to use this approach, suitable reference areas must be available . The decision to use reference areas will ultimately depend upon decisions regarding the risk assessment strategy (Subtask 1.6), upon the availability of suitable reference areas, and the presence of appropriate populations and communities for measuring the necessary ecological endpoints. The decision process for using reference areas is presented in Figure 8-4.

Reference areas will be selected according to procedures presented in SOP 5.13–Development of Field Sampling Plans, and the criteria developed in Subtask 1.4. Reference areas for terrestrial sites will be selected on the basis of habitat type (see SOP 5.11–Identification of Habitat Types), soil series, topography, and aspect. Reference areas for aquatics will likely be limited to selecting a small front range reservoir similar to Mower Reservoir. Selection criteria would include lake size and depth, water source, tendency for stratification, substrate type, and shoreline vegetation.

8.2.2.4 Subtask 2.4–Develop Initial Ecological Risk Assessment

This subtask will use all the information acquired during Task 1 and Subtasks 2.1 to 2.3 to conduct a preliminary ecological risk assessment. The principal objectives of this exercise will be to assess the appropriateness of the risk assessment strategies that were proposed in Subtask 1.6, identify data gaps, and determine how to fill the data gaps. The preliminary assessment will be based on some assumptions and the conceptual exposure models developed in Subtask 1.5. During subsequent tasks in the EE, the assumptions could be verified and the conceptual models would be

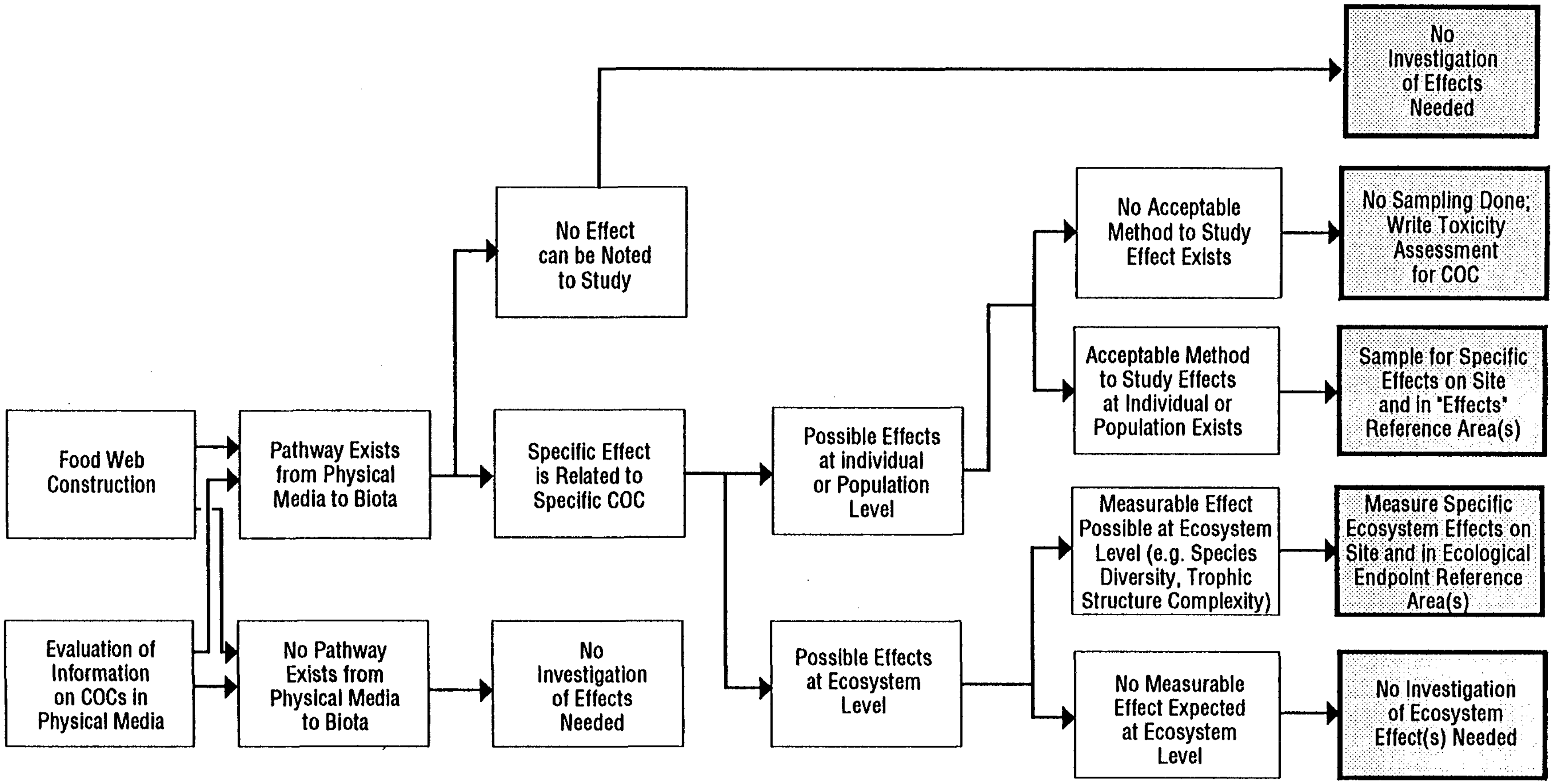

Figure 8-4
Decision Process for the Investigation of Target Species, Population, and Ecosystem Level Effects and for the Use of Reference Areas for COC Effects

DRAWN BY	Douville 11/06/91	CHECKED BY	REM 11/07/91	11/23/91	DRAWING NUMBER	RF1027
		APPROVED BY	Au	11/25/91		

updated. The preliminary risk assessment will address the COCs and target species selected in Subtask 2.3.

The initial ecological risk assessment will identify the potential hazards and exposure pathways at OU 3 and determine if exposure pathways are complete. A complete pathway must include a contaminant source, release mechanism, transport medium, exposure route, and an intake (uptake) mechanism into the receptor. This subtask will also evaluate the fate and transport of the COCs, to the extent possible using available data. Available data will be used to prepare preliminary toxicity assessments for the COCs, and develop toxicity profiles. During preparation of the preliminary risk assessment, the techniques proposed for assessing risks will be evaluated. Information will be accumulated to developed dose-response data sets for the COCs, where possible, and determine which COCs and target species can be studied using a toxicity based approach. Similarly, the comparative ecological approach will be evaluated for other COCs and/or target species, and if the approach is deemed appropriate specific ecological endpoints will be selected. The potential impacts of RFP-related contaminants on target species or taxa will be estimated, to the extent possible using available information.

The development of a preliminary ecological risk assessment will clearly show where data gaps exists. These data gaps may indicate the need for more information on the natural background concentrations of COCs (for example uranium and plutonium), more data on OU 3 contaminant concentrations, more information on the fate and transport of some COCs, or more information to determine the uptake of a COC by a particular biological receptor.

8.2.2.5 Subtask 2.5—Review and Modify Strategy and Field Sampling Plan

A substantial quantity of new information will be acquired during Tasks 1 and 2. This new information will be used to confirm if appropriate COC and target species were selected, and determine if the techniques proposed for the EE are suitable and adequate. This information also will be used to evaluate and revise the conceptual exposure models. Therefore, the last subtask in Task 2 will be to assess all the information and knowledge acquired at that point, and review and modify the risk assessment strategy prepared in Subtask 1.6. Appropriate revisions would also be made to the exposure models if necessary.

Finally, the FSP presented in the EEWP as Subsection 8.3 will be reviewed and revised as necessary before implementing the field activities described in the following Task 3. The proposed comparative ecology studies will be evaluated to make sure that appropriate ecological endpoints will be used, and the proposed toxicity studies will be evaluated and revised to address the final list of COCs and target species. Also, if reference areas are proposed, a site visit would be conducted to confirm that the reference areas are comparable to the test areas within OU 3, and that the reference areas are selected in accordance with EE work at other OUs. The FSP will also be reviewed to assess its compatibility to the NRDA program.

8.2.3 Task 3—Ecological Investigations

The primary objectives of this task will be to characterize the site with respect to ecological resources and acquire data to determine the ecological consequences of selected COCs. The activities conducted for this task, therefore, will include qualitative and quantitative surveys to characterize the populations and communities at OU 3, and quantitative comparative ecology studies to measure ecological endpoints that might reflect the effects of site-related contaminants. These types of activities are referred to in this EE work plan as ecological-based assessment approaches that generally require only non-destructive sampling.

This task will also include collecting plant and animal samples and analyzing these to measure the amount of contaminants in the tissue. This type of sampling is destructive, and provides data for toxicity-based approaches. Toxicity testing, described under Tasks 4 and 9, is another type of destructive sampling. The destructive sampling activities that provide data for toxicity based approaches are referred to in this EEWP as ecotoxicological investigations.

This task is primarily field studies that are grouped into four subtasks, and three of the four are ecological investigations. The sampling methods and protocol for these activities are presented in detail in Subsection 8.3, titled Field Sampling Plan.

8.2.3.1 Subtask 3.1–Site Characterization Program

Qualitative and quantitative field studies will be conducted to characterize the abiotic and biotic components of the ecosystems at OU 3. Qualitative field surveys will be conducted in the spring, summer, and fall to observe and record the plants and animals present within the OU, map habitat types, and investigate the interrelationships between the biotic and abiotic components. The qualitative surveys will be conducted to improve the initial site characterization developed in Task 2, that was based on existing reports and data bases. These surveys will also be used to search for threatened and endangered species, and confirm the accuracy of maps prepared from the initial site visit of areas of special concern such as wetlands and riparian zones.

The physical and chemical data required to characterize the abiotic components will be collected during the qualitative field surveys using observations and field instruments; and via analyzing the soil, sediment, and water samples collected during the RFI/RI sampling described in Section 6.0. The objective of this sampling is to determine the presence, absence, and concentration gradients of potential site contaminants. Although the media sampling, and the ecology sampling described for this task is referred to as the environmental evaluation sampling, both biotic and abiotic components will actually be surveyed and collected during the same time period, sometimes by the same field crew.

Data on abiotic media will be collected to determine to presence or absence, and concentration gradients of COCs within OU 3. Data on air quality and transport of airborne particulates will be obtained from existing reports and the ongoing sitewide air quality monitoring program at the RFP. These data will be used to assess exposure via inhalation for those COCs and target taxa where that pathway is considered to be significant (Subtasks 1.5 and 2.4). Surficial soil samples will be of prime importance for determining source contaminants for biota. This uppermost layer is a major source of nutrients and contaminant uptake for the vegetation under study and is also a potential source of contaminants to soil dwelling animals and invertebrates, and their predators. Also, fluids moving through the soils can leach contaminants, transport them through available flow paths, and deposit them in downgradient environments.

Data on contaminants in surface water and sediments at OU 3 will be required because the drainages represent a principal transport mechanism for moving COCs from the RFP to OU 3. The preliminary conceptual model for OU 3 (Figure 8-3) also indicates that surface water and sediments are important transport media to both aquatic and terrestrial organisms.

Quantitative samples of selected target taxa (populations and communities) will be collected during the spring and summer to provide site characterization data. For example, plant communities will be sampled to determine dominant species, variety of plants present, percent cover, and plant biomass. Animal populations and communities will be sampled to determine relative abundance of the more common species, spatial distribution, seasonal occurrence of different life stages, evidence of reproductive success, and diversity of species within the community.

The general biological components of OU 3 have been described by previous investigations (DOE, 1980 and 1991a; DOW, 1975; CSU, 1974). However, more site-specific information must be acquired to adequately describe the biological receptors at OU 3 and understand the relationships between these receptors and between the receptors and their physical environment. Methods identified and described in the Ecology SOPs (Volume V) (EG&G 1991b) will be used in collecting biological data and samples, and a detailed field sampling plan is presented in Subsection 8.3. The emphasis will be to describe the structure of the biological communities at OU 3 in order to identify potential contaminant pathways, biotic receptors, and target species.

8.2.3.2 Subtask 3.2—Acquire Exposure Information

The qualitative and quantitative field investigations described in Subtask 3.1 will also be designed to acquire additional information on exposure pathways, habitat preferences of target taxa, and food habits. The conceptual model developed in Subtask 1.5 and the initial ecological risk assessment developed in Subtask 2.4 will identify data needs for completing the exposure pathway analyses. These data gaps will be filled, if possible, during this subtasks.

One objective of this subtask will be to verify that the exposure pathways between COCs and target taxa that will be evaluated quantitatively are complete. To quantitatively evaluate exposure pathways, much of the information on home ranges, intake rates, and food and habitat preferences will be obtained form the literature. However, field studies will be used to fill data gaps in the literature base and verify that the data and information obtained from scientific reports is applicable to the environmental conditions at OU 3.

8.2.3.3 Subtask 3.3—Conduct Comparative Ecology Studies

In many cases, there is not enough information in the existing literature to estimate intake rates, understand how contaminants are metabolized, or define acceptable intake levels. This is true for the concentration levels of plutonium already measured or expected on OU 3, with averages estimated at 0.085 to 22.1 picocuries per gram (pCi/g) (DOE 1991a, 1991b). In these cases, it is more appropriate to develop a field program to measure an indicator of contaminant stress (toxicity) rather than undertake the extensive laboratory and field studies needed to assess the toxicity using the quantitative dose-response approach. These indicators of contaminant stress are referred to as "ecological endpoints." Rather than trying to assess toxicity itself, the ecological endpoint approach measures a specific end result of toxicity, such as a decrease in the growth of plants or a change in the relative abundance of species that are sensitive or insensitive to certain contaminants.

Since natural ecosystems respond to numerous parameters such as temperature changes (abiotic) and predation pressures (biotic), as well as to toxic substances (the COCs), the ecological studies are usually designed to measure specific ecological endpoints in both contaminated test areas and uncontaminated reference (control) areas. The assumption of this approach is that the populations or communities being studied in the test and reference areas are identical, except for the presence of the COCs in the test area. Therefore, if differences are measured in the ecological endpoints, the differences are due to the effects of the COCs. The selection of the reference areas is critical, and has been described previously in Subtasks 1.4 and 2.3. In some cases it may be possible to detect the influence of a contaminant by measuring an ecological endpoint in the test area, and comparing that data to information obtained form existing literature.

There are numerous ecological endpoints that can be used to measure potential differences between teat and reference areas. Ecological endpoints at the population or community levels are frequently easier to quantify than those at the ecosystem level because of the greater inherent variability at the more complex ecosystem level. However, some endpoints at the ecosystem level, such as nutrient loss or retention, can be easy to measure and sensitive to some contaminants. Examples of ecological endpoints include:

- Population abundance–number of individuals of one species in a given area
- Age structure–number of individuals within several age classes or life history stages in the population
- Standing crop–total biomass in an area
- Species diversity–the number of species within a community in a particular area
- Trophic diversity–the number of different trophic levels within a community or ecosystem in a particular area.

The target taxa, reference areas, and ecological endpoints that will be used for this subtask will be selected during Task 2 (Subtasks 2.2, 2.3, and 2.4), and the field procedures will be designed into the field sampling plan during Subtask 2.5. Ecological endpoints will be selected using criteria developed in Task 2. Criteria for good endpoints might include:

- Sensitivity to the contaminant of concern

- Ability to measure the endpoint accurately
- Availability of information on the endpoint in the literature
- Consistent and easily recognized response to the contaminant.

If differences are observed in one or more ecological endpoints between test and reference areas, then additional studies may be necessary to determine if the observed differences are the result of contamination rather than some other factor. If additional studies are required they will be planned during Task 8 and conducted during Task 9.

8.2.3.4 Subtask 3.4—Measure Bioconcentration

During Task 2.3 the COCs will be selected, and existing toxicology literature will be reviewed to determine which of the COCs will bioaccumulate in living organisms. During Task 3, appropriate target taxa will be collected and tissue samples will be analyzed for contaminant concentrations. At this point in time, tissue sampling is planned for vegetation, small mammals, benthic macroinvertebrates, and fish (see Subsection 8.3, titled Field Sampling Plan).

If bioaccumulation is detected, then there is direct evidence that the exposure pathway is complete. However, the occurrence of bioaccumulation does not necessarily equate to toxicity because the contaminant may be stored as a non-toxic form or may accumulate on the exterior of the receptor (for example, benthic macroinvertebrates). The bioconcentration values in test organisms, therefore, will be compared to literature information and bioconcentration values for organisms from reference locations to assess toxicity. Also, where possible, tissue concentrations will be compared to contaminant concentrations in the abiotic media to calculate a bioconcentration factor (BCF). Then the BCFs will be compared to those reported in the literature.

8.2.4 Task 4—Toxicity Assessment

The toxicity based assessment includes Tasks 4 through 7. The two primary objectives of the toxicity assessment are to: (1) obtain quantitative information on the types, concentration, and distribution of contaminants in selected species, and (2) evaluate the effects of contamination on target species in the ecosystems.

Toxicity based impact assessment requires an evaluation of chemical and radiological exposures and the actual or potential toxicological effects on target species. Specifically, the assessment should identify exposure points, contaminant concentrations at those points, and potential impacts or injury. The toxicity assessment for OU 3 will be based on existing environmental criteria, published toxicological literature, and existing site-specific data. The program will be integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to biota exposures. The objectives and description of work for each of the toxicity based impact assessments tasks are presented below.

The purpose of the toxicity assessment is to weigh the available evidence regarding the potential for the contaminants of concern at OU 3 to cause an adverse effect on the target species. The toxicity assessment will be structured to provide answers to questions such as:

1. What are the adverse effects of the contaminant?

2. How toxic is the contaminant to the receptors in question?

3. What environmental conditions influence the toxicity of the contaminant?

4. What relationships exist between the magnitude and frequency of the exposure and the increased likelihood and/or severity of the adverse effects?

5. What are the uncertainties involved in assessing toxicity?

8.2.4.1 Subtask 4.1—Prepare Toxicity Profiles

Toxicity profiles for each COC will be developed from existing scientific literature to describe the adverse effects that the contaminant may have on vegetation or terrestrial and aquatic animals. This process will also include describing what factors may influence the toxicity of the contaminant (for example, in aquatic environments increasing water hardness decreases the toxicity of several metals). It will also aid in determining possible adverse responses to the contaminant of concern, considering the abiotic and biotic environment at OU 3.

8.2.4.2 Subtask 4.2—Evaluate Toxicity Values

The most fundamental concept in toxicology is that a relationship exists between the dose of an agent and the response produced in a living organism. The process of quantitatively evaluating the toxicity information developed in the toxicity profile and characterizing the relationship between the dose of the contaminant received and the incidence of adverse effects on the target species provides toxicity values that express the dose-response relationship. These toxicity values can be used to estimate the incidence, or potential for adverse effects, as a function of receptor exposure to a contaminant.

Numerous laboratory and in-stream toxicity experiments have been conducted with aquatic organisms to determine what concentrations of a given contaminant cause adverse effects (EPA, 1986a and 1985a). The results are frequently expressed as the concentration of the contaminant in water that causes a certain percentage of mortality over a given time period. For example, the 96-hour LC_{50} (lethal concentration) is the concentration that kills 50 percent of the test organisms within a 4-day test period. Other experiments are designed to measure chronic effects over longer time periods, such as the concentration of a contaminant that causes a reduction in growth or reproduction in the test population. The results of chronic tests are sometimes expressed as the NOEL and LOEL: the concentration that causes no observable adverse effects and the lowest concentration that produces a significantly different response in test and control populations, respectively.

Similar experiments involving terrestrial animals are usually designed to determine what dose (intake per body weight per time) of a given contaminant will produce an adverse effect. The results are frequently expressed as a LD_{50} and the lowest chronic dose to elicit an adverse observable effect. These toxicity values will be compared to the concentrations of contaminants at surface water exposure points (for aquatic organisms), or estimated intakes of contaminated prey or vegetation (for terrestrial organisms) to assess the toxicity of contaminants at OU 3. In assessing toxicity based on experiments presented in the literature, care must be taken to consider how the experimental conditions differ from the conditions at the offsite area, and how these differences may affect toxicity.

Under the authority of the Clean Water Act, the EPA has developed federal water quality criteria for the protection of aquatic organisms. Numerical criteria for more than 120 organic and inorganic contaminants have been published in EPA's Quality Criteria for Water (EPA, 1986a). Likewise, water quality criteria for protection of humans (and terrestrial animals) have been developed for sources of drinking water. State regulatory agencies have used these criteria, as well as criteria from the Safe Drinking Water Act, to establish water quality standards for the protection of beneficial uses of state waters. The EPA has also developed National Ambient Air Quality Standards (NAAQSs) for a few key air pollutants under authority of the Clean Air Act. Standards for many more toxic air pollutants will be developed under the Clean Air Act amendments of 1990. Other state and federal agencies have developed soil criteria for protection of agricultural lands or as goals for remediation of hazardous waste sites. These water, air, and soil criteria/standards will be used as another set of toxicity values to assess the potential toxicity of OU 3 contaminants.

8.2.4.3 Subtask 4.3—Conduct Toxicity Tests

In some cases, it will be easier to assess the potential toxicity of contaminants in soil, sediments, and water at OU 3 by directly measuring toxicity. Toxicity tests for a limited number of target species will be conducted to supplement the toxicity assessments based on dose-response evaluations and comparisons to criteria. The dose-response evaluations and comparison-to-criteria approach, addressing one contaminant at a time, do not incorporate potential synergistic or antagonistic effects that may occur when more than one contaminant is present. Likewise, these approaches may not reflect the physical and chemical nature of the receiving water or soil at OU 3 or the actual bioavailability of the contaminants. Therefore, direct measurement of toxicity using toxicity tests will provide important supplemental information to the overall toxicity assessment.

Toxicity tests will be conducted in the laboratory using water, sediment, and possibly soil collected from OU 3 areas expected or known to be contaminated. For aquatic organisms, standardized acute and chronic tests using established EPA procedures will be conducted (EPA, 1985a, 1985b, 1989e). Toxicity tests developed for soil microbes, earthworms, crickets, and grasshoppers will be reviewed and considered for assessing OU 3 toxicity to terrestrial invertebrates (EPA, 1989e).

In summary, the toxicity assessment will include a summary of potential adverse effects on biota associated with exposure to OU 3 contaminants,including, where appropriate, comparisons of estimated exposure concentrations relative to published concentrations at which toxic effects are known. Potential toxic or other effects on target species will also be characterized using EPA critical toxicity values (when available) in addition to selected literature pertaining to site- and receptor-specific parameters. The toxicity assessment will include brief toxicological profiles for COCs, and their known distribution and fate in environmental media. The profiles will cover the major deleterious effects information available for each COC. Data pertaining to wildlife species will be emphasized, and information on domestic or laboratory animals will be used when wildlife data are unavailable. The toxicity assessment may include conducting in-situ or laboratory toxicity tests on some target aquatic or terrestrial species. Uncertainty analyses of the toxicity information for this site will be performed.

8.2.5 Task 5—Exposure Assessment

The exposure assessment will describe how the potential contaminants are transported from source areas to the receptors, taking into account the environmental fate and transport of the contaminant through both physical and biological processes. The exposure assessment will also determine the susceptibility of different receptors to the contaminants at OU 3 due to: (1) their proximity to areas with the highest contaminant concentrations, (2) the receptor's reliance on contaminated food, or (3) the receptor's presence in contaminated habitats for long durations. The exposure assessment process involves: (1) developing exposure pathways for the OU 3 contaminants of concern and target species (receptors), (2) determining logical exposure points for each receptor and measuring or estimating the concentrations of the contaminants at those exposure points, (3) estimating the uptake of the contaminants by the receptor, and (4) identifying appropriate ecological endpoints (see Figure 8-1). The exposure assessment will use site-specific data and available information in the scientific literature to address the following questions:

- What are the significant routes of exposure at OU 3?
- What receptor(s) are actually exposed to contaminants from OU 3?
- To what concentration of each contaminant are the receptor(s) actually or potentially exposed?
- How often will the exposure take place and what is the duration of exposure?
- What subpopulations, age groups, or life stages are most susceptible?
- What seasonal and climatic variations are likely to affect exposure?
- What are the site-specific geophysical, physical, and chemical conditions affecting exposure?

8.2.5.1 Subtask 5.1—Develop Exposure Pathways

Exposure pathways will be developed to qualitatively describe how the contaminants of concern can be transported from their sources to the target receptors, and to determine if complete exposure pathways exist. The conceptual model developed for the site will identify potential exposure pathways. A complete exposure pathway has five components. All components must be present or exposure will not occur. These five components are:

1. Chemical/radionuclide source
2. Mechanism of release to the environment
3. Environmental transport medium (e.g., soil, water, air) for the released chemical/radionuclide
4. Point of potential biological contact (exposure point) with the contaminated medium
5. Biological uptake mechanism and absorption (dose) at the point of exposure.

Aspects of the life history of each target species, such as phenology, food habits, preferred habitat, and seasonal behavior will be evaluated to determine where the aquatic and terrestrial organisms will likely be exposed to contaminants at OU 3. This evaluation will be coupled with fate and transport information on the contaminants of concern to determine which contaminants are likely to be transported to which exposure points. An interactive process, based on the above information, will be used to identify the most logical exposure points. The exact exposure points will vary, depending on both the contaminant and the target receptor species under consideration.

The most probable exposure pathways to the biological receptors within OU 3 will be assessed and several pathways will be selected for detailed analysis. Pathways will be developed for the four transport media: air, soil, surface water, and sediments. These exposure pathways will be evaluated and modeled, where possible. Since fish and wildlife may obtain contaminants through their food supply, migration of constituents through the food chains at OU 3 must be incorporated into the exposure assessment analyses.

8.2.5.2 Subtask 5.2–Assess Exposure Point Concentrations

Exposure points are locations where receptor species may contact COCs. Initial identification of exposure points will result from the pathways modeling described above. Fate and transport modeling will then be used to assess exposures for target species. The exact exposure points can be expected to vary, depending on both the contaminant and the target species under consideration. After the exposure points have been identified, actual field measurements or fate and transport modeling will be used to estimate the concentration of each contaminant at the exposure point. This procedure will rely directly on the abiotic field program to provide measured concentrations at exposure points and/or provide input for modeling efforts. Where possible, the average and maximum concentrations for each contaminant will be measured or estimated to evaluate average and maximum conservative exposure scenarios.

8.2.5.3 Subtask 5.3--Evaluate Contaminant Intake Processes

This subtask will evaluate the methods for contaminant uptake (such as inhalation or ingestion) for each of the target receptors under consideration. The chemical and radiological uptake will be estimated using appropriate conservative assumptions, site-specific data, and existing or forthcoming exposure methodology similar to those for humans in EPA's Superfund Exposure Assessment Manual, (EPA, 1988c). This subtask, where possible, will estimate the quantity of contaminant taken up on a daily or longer-duration basis by the target receptors from the various environmental media via inhalation, ingestion, dermal contact, and other processes. This actual (estimated) uptake will be compared to the acceptable intake (or exposure) to assess risks.

In the case of terrestrial vegetation and aquatic organisms, the typical approach of comparing actual intake to acceptable intake of ingested or inhaled contaminants is not very appropriate. Since vegetation is continuously exposed to contaminants in soil, estimates of uptake are based on transport of contaminants from soil (and soil water) via the roots. Incorporation of airborne contaminants deposited on leaves and other aboveground plant tissues must also be considered. In the case of freshwater organisms, the primary uptake mechanism is frequently transfer of dissolved contaminants by absorption across the gill membranes or the integument. Aquatic animals can also take in contaminants by ingesting contaminated prey and sediments, although these mechanisms are generally less important than direct uptake across gill membranes.

Information derived from the exposure assessment will also be used to select sampling locations for toxicity tests and to determine which locations might be best for comparative ecology studies.

8.2.6 Task 6—Contamination Impact and Risk Assessment

Contaminant risk characterization entails integration of exposure concentrations with the information developed during the exposure and toxicity assessments to characterize current and potential adverse biological effects (e.g., death, diminished reproductive success, or reduced population levels) posed by OU 3 contaminants. In addition, ecological consequences other than the toxicity based assessment will be performed. The potential impacts from several exposure routes (root uptake, foliar deposition, inhalation, ingestion, and dermal contact) and different media (air, soil, groundwater, and surface water/sediment) will be included in this evaluation, as appropriate (U.S. EPA, 1989e).

Characterization of adverse effects on plant and animal receptors is generally more qualitative than characterization of human health risks because the toxic effects of most chemicals, and their environmental fates and interactions, have not been well characterized for natural ecosystems. Criteria that are suitable and applicable for evaluation of ecological effects are generally limited. Criteria set forth in federal and Colorado laws and regulations pertaining to preservation and protection of natural resources will be used where available. Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act (TSCA) or the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

In accordance with EPA guidance (1989d, 1989e), priority will be placed on the adverse toxic effects of chemicals at the ecosystem, community, and population levels rather than effects on individual organisms. These adverse effects can be estimated using a "weight-of-evidence" approach by comparing contaminant intakes to acceptable values, exposure point or dose estimates to toxicity values in the literature, and ecological endpoints in target taxa in test and reference areas.

8.2.6.1 Subtask 6.1—Evaluate Toxicity Based Effects

Where specific information is available in published literature, a quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance

(U.S. EPA 1989d). The risk assessment process will also include evaluating the results of toxicity tests at OU 3 or results at other OUs, and the bioconcentration data. Quantitative estimates of effects may be calculated by converting the conceptual model into logic diagrams and assigning probabilities to the steps in the model. The method for determining contamination effects will depend on the outcome of the EE procedures in providing site specific information.

8.2.6.2 Subtask 6.2—Determine Ecological Consequences

When it becomes difficult, expensive, or impossible to develop quantitative dose-response types of toxicity values for the particular species or contaminant of interest, an ecological consequences approach will be used to assess the adverse effects of the contaminant. In the ecological consequences approach, an ecological endpoint is measured within an impacted population. The ecological endpoint is an indicator of an adverse effect on the exposed population. That measurement is then compared to the same endpoint in a nonimpacted population such as in a reference area.

This approach evaluates the possible relationship between the ecological endpoint (such as increased mortality or slower growth rate) and one or more of the site contaminants. The approach also provides an assessment technique for contaminants that are not directly toxic to plants and animals. For example, some contaminants may decrease the available oxygen in an aquatic ecosystem with catastrophic effects even though they are not directly toxic to the organisms.

The ecological consequences of a contaminant are frequently determined by measuring one or more ecological endpoints in a population exposed to contaminants, and comparing these to the same endpoints in a control population at an unimpacted reference area. However, ecological endpoints for exposed populations can also be compared, in some cases, to information in the scientific literature to determine if the exposed population is affected. Both of these approaches are referred to as comparative ecology studies.

The ecological consequences of contaminants at OU 3 may also be assessed by measuring the bioaccumulation of certain contaminants within the tissues of individual organisms, and comparing these levels with levels reported in the scientific literature. Finally, the potential impact of some contaminants can be assessed by measuring the frequency of occurrence of certain biomarkers (such as skeletal abnormalities or presence of metal-binding proteins) in the exposed populations. All three methods of evaluating ecological consequences (comparative ecology studies, bioaccumulation and biomarker monitoring) have been presented and discussed in Section 1 as Subtask 1.6, and are discussed below as applied to OU 3.

8.2.6.2.1 **Comparative Ecology Studies.** The toxicity of a given contaminant to individual organisms can have consequences on biological populations, communities, and ecosystems. For example, a contaminant that increases susceptibility to predation or decreases reproductive success in individual organisms will cause a decrease in population size (a population is a group of individuals of the same species). The decrease in population size may, in turn, change the relative abundance or distribution of that population with respect to other populations in the community (a community is a group of populations in the same location or habitat). The community change may, in turn, lead to ecosystem effects such as alterations in nutrient cycling.

There is a general consensus that adverse effects of contaminants can be assessed by measuring ecological endpoints at the population level (EPA, 1989e) and, to a lesser extent, at the community level. However, it becomes increasingly difficult and expensive to measure consequences at the ecosystem level since the influence of a multitude of factors, in addition to the effect of the contaminant, come into play. Therefore, at OU 3, the comparative ecology studies will be designed primarily to measure population and community parameters.

To effectively characterize the effects of contaminants on a population, one or more ecological endpoints should be selected. These endpoints represent responses the population is expected to exhibit as a result of exposure to the contaminant in question. Examples of ecological endpoints at the population level would include decreases in growth rate and fecundity, increases in frequency of disease or death, or changes in the relative abundance of different life stages. Ecological endpoints should be selected based on the capability to measure the endpoint, and the likelihood that the endpoint would respond to the COC.

Comparative ecology studies are one way of establishing whether an ecological impact has occurred in a quantitative sense. These studies may quantify the impact of site contaminants on populations and provide a means of evaluating the magnitude of the difference between impacted and nonimpacted populations. Comparative ecology studies at OU 3 will be directed at two terrestrial communities: prairie vegetation and small mammals; and two aquatic communities: fish and benthic macroinvertebrates (see Subsection 8.3).

8.2.6.2.2 Bioaccumulation and Biomarker Studies. Some metals (such as mercury in aquatic organisms) will accumulate in living organisms at concentrations much higher than in the media to which the organisms are exposed. One or more processes may be involved. For example, some organisms can convert the contaminant to a less toxic or nontoxic form and store it, or the contaminant may have an affinity for fatty tissue and preferentially accumulate in organs containing a high proportion of fat. Since the stored or accumulated contaminant may be converted to a nontoxic form, bioaccumulation does not necessarily equate to an increase in toxicity.

The potential bioaccumulation of selected contaminants will be measured at OU 3 in fish, benthic macroinvertebrates, vegetation, and small mammals such as prairie dogs. Bioaccumulation data will be used for the three purposes listed below.

1. Data from OU 3 will be compared to bioaccumulation levels in scientific literature to help evaluate the potential impact of the contaminants on the plants and animals that accumulate the contaminants.

2. Data at different trophic levels will be evaluated to determine if OU 3 contaminants are being transferred within food chains. If this occurs, there may be significant impacts on higher predators such as raptors and fish.

3. Data for organisms that serve as food sources for humans may be used in the human risk assessment process to determine if there are potential health risks from using those resources.

Biomarker studies involve measuring responses in individual organisms which indicate that the organism has been exposed to a particular contaminant. Generally, a biomarker is a biochemical or physiological response that can be detected even at low-exposure levels. Examples of biomarkers include: a change in the frequency of a genetic abnormality; a histological change in tissue structure; or a physiological response, such as increased production of the metal binding protein, metallothionein.

There are many advantages to using biomarkers in ecological assessments, including: broad applicability to many taxonomic groups; the ability to link field surveys to laboratory tests to interpret the significance of field results; and the fact that some biomarkers are diagnostic of specific contaminants. However, there are currently few accepted, standardized, and tested biomarkers for many of the contaminants found at hazardous waste sites. Also, the relationship between the measured biomarker response and population-level effects has not been defined in many cases. Further, biomarker studies are expensive to conduct. The existing scientific literature on biomarker monitoring will be reviewed during Task 2 to determine if this approach may be useful for the target species and contaminants of concern at OU 3. If biomarker studies could add to or support the assessment of risks in the offsite area, they would be planned and incorporated in Task 9—Ecotoxicological Investigations.

8.2.7 Task 7—Uncertainty Analysis

The uncertainty in the EE process will be analyzed which identifies assumptions, and the sources and magnitude of errors. All risk estimates are dependant on numerous assumptions and consideration of the many uncertainties that are inherent in the ecological risk assessment process. In any evaluation of the level of risk associated with a site, it is necessary to address the level of confidence of the uncertainty associated with the estimated risk.

8.2.7.1 Subtask 7.1—Identify Assumptions and Evaluate Uncertainty

The process of assessing ecological effects is one of estimation under conditions of uncertainty. The estimates are dependent on numerous assumptions and other sources of uncertainty such as toxicity and exposure assessments, measurement variability, and variability of natural ecosystem processes. To address uncertainties, the OU 3 Environmental Evaluation will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. The level of confidence will be addressed by quantifying the results of the assessment. Factors that limit or prevent development of definitive conclusions will also be discussed.

8.2.7.2 Subtask 7.2—Specify Sources of Uncertainty

In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Inherent natural variability within the population or community being assessed: variations in natural ecosystems are cyclic and seasonal, and occur in response to abiotic factors such as temperature and moisture conditions

- Variability introduced when parameter values from laboratory data or literature information is used to extrapolate to field situations in unmanaged ecosystems

- Variance estimates for all statistics

- Assumptions and the range of conditions underlying use of statistics and models.

A narrative explanations of other sources of potential error will be included, and discussed as to how the errors affect the risk assessment.

8.2.7.3 Subtask 7.3—Identify Additional Data Needs

The variances and errors leading to uncertainty can be reduced by increasing the precision of measurements, or by taking additional samples or surveys. The validation and calibration of pathway models will be used, where practicable, to reduce uncertainty. The uncertainty analysis process will also be used early in the EE to help identify additional data needs such as additional tissue samples or field surveys.

8.2.8 Task 8—Final Planning

Task 8 will be initiated after Tasks 1 and 2 have been completed, and after Tasks 3, 4, and 5 are well underway. The information gained from spring and early summer field investigations, and from the assessment of exposure pathways and toxicity of COCs, will be used to plan additional field studies (Task 9). These field studies will include toxicity testing, collecting tissue samples, and conducting additional ecological studies to provide seasonal data and/or increase the data base. The spring and early summer field investigations may indicate that additional COCs are needed, or additional background or reference area data are required. The methods used for additional sampling will be consistent with the Ecology SOP (EG&G, 1991b) and the methods used in Task 3, or will be modifications of these methods based on the experience gained in Task 3.

8.2.8.1 Subtask 8.1—Identify Data Needs

Data from Task 3, including abiotic sampling, and the development of exposure pathway models and toxicity assessment data, will be used to determine which additional field activities are most appropriate for OU 3. Plans developed in Subtask 2.5 for seasonal sapling will also be incorporated into this planning task and the subsequent Task 9 field investigations.

The Task 9 sampling program will target specific COCs, target species, and exposure pathways based on the information acquired from Tasks 1 through 7. Toxicity tests may include additional chronic toxicity testing to follow up on positive results from Task 3 toxicity tests, in-situ toxicity testing to support earlier laboratory tests, and implementation of toxicity tests on terrestrial organisms. Additional tests may also be conducted to determine the cause of toxicity.

The decision process for conducting tissue analyses or effects in target taxa is presented in Figure 8-5. Tissue sampling will be conducted for only the COCs that bioaccumulate. Whole-body sampler and individual tissues will be analyzed to assess the potential impact on the organism itself, or on human or natural predators. Suitability of a species for tissue sampling will depend on its position in the food web and its abundance at the site.

To the extent possible, tissue samples will be collected simultaneously with environmental media samples, This will allow for determination of site-specific BCFs, which will then be incorporated into the exposure assessment for use in calibrating/validating the pathways model. Where BCFs cannot be determined, published or predicted BCF values will be used in the pathways model to assess potential impacts.

8.2.8.2 Subtask 8.2--Develop Specific DQOs

During this subtask the DQOs established in Subtask 1.3 will be reviewed and revised if necessary, and additional DOQs will be established specific to the Task 9 ecotoxicological investigations. The DQOs will be developed using the three-stage process, and addressing the same principal objectives described in Subtask 1.3. The data uses and needs described in Subsection 5.2 will be reassessed based upon the information acquired during Tasks 1 through 7, and incorporated into the FSP for Task 9 (see Subtask 8.3).

More specific DQOs will be formulated on the basis of the proposed ecotoxicological sampling and will address the following:

- Number and types of analyses
- Species, locations, and tissues to be sampled
- Number of samples collected

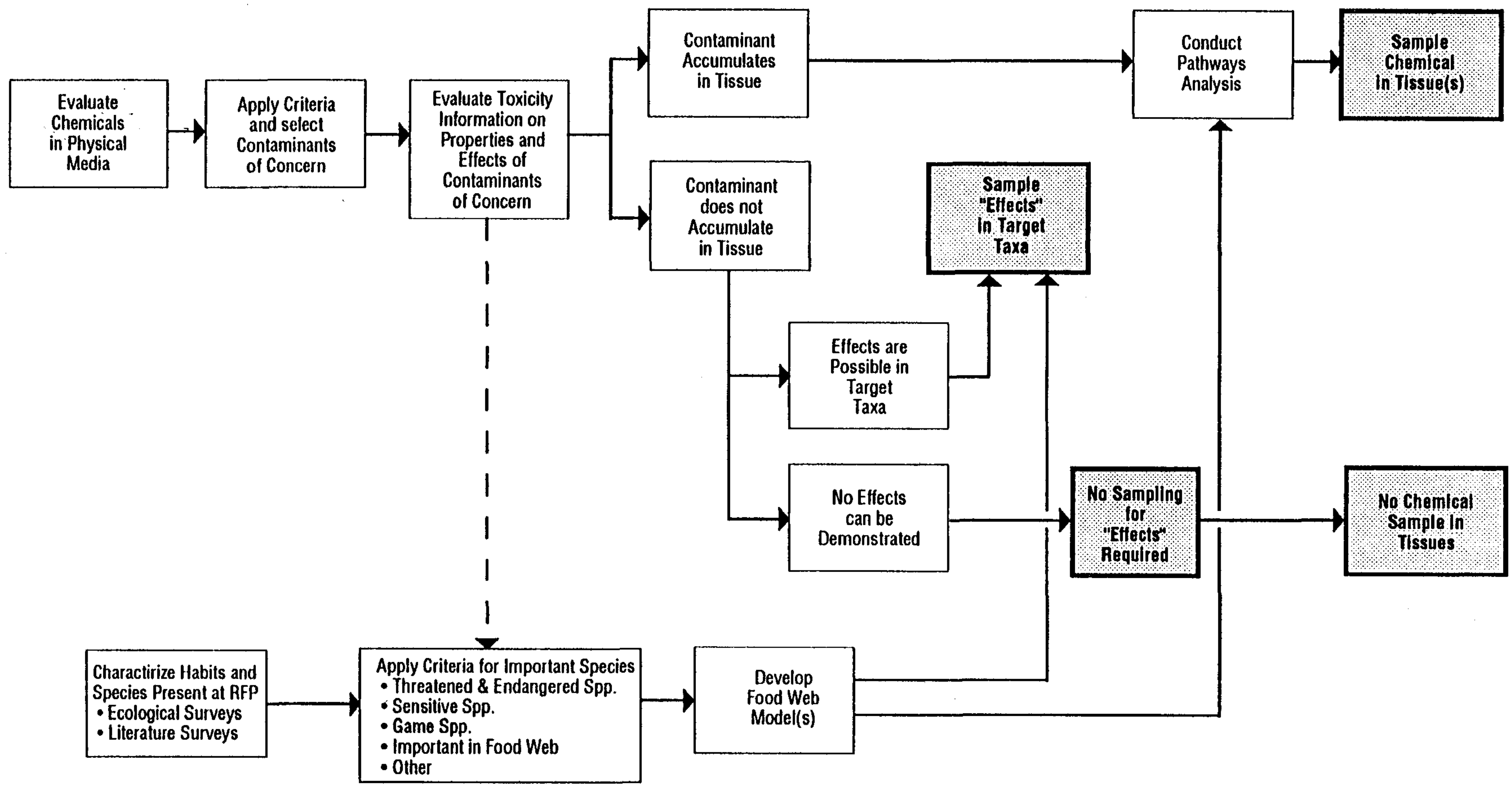

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Figure 8-5
Decision Process for Chemical Sampling of Tissues or Effects in Target Taxa

- Detection limits for contaminants
- Acceptable margin of error in analyzing results.

Additional comparative ecology studies will be conducted during the Task 9 ecotoxicological investigations to obtain seasonal data and build on the data started in Task 3—Ecological Investigations. As described in Task 3, the ecological endpoints for measuring the effects of contaminants will be carefully selected to maximize the effectiveness of the field investigations. Some of the criteria for selecting ecological endpoints are:

- The methodology and measurement endpoint must be appropriate to the exposure pathway

- The endpoint response to the contaminant is well defined, easily identifiable, and predictable

- The contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms

- The available sample size is large enough to make the measurement useful.

Additional tissue samples will be collected during the ecotoxicological investigations to obtain bioaccumulation data from additional locations, or on new target taxa or COCs. Tissue sampling in late summer and fall will also be done to monitor potential seasonal variations. Tissue samples will generally be collected from test areas within OU 3 and from uncontaminated reference areas because several of the COCs are present at background levels in natural environments (for example, lead and uranium). Also, the existing literature may not provide the information needed to determine if a given level of the contaminant in body tissue is toxic to the organism itself or potentially harmful to predators. The decision process for the use of reference areas in tissue sampling is shown in Figure 8-6.

8.2.8.3 Subtask 8.3—Prepare Field Sampling Plan

A detailed FSP, including cost estimates, will be prepared for the ecotoxicological investigations and submitted to EG&G and DOE for approval. The FSP will provide the rationale for the type of sampling planned for Task 9 (for example; tissue sampling, toxicity testing, and ecological endpoint sampling) and identify any new COCs or target taxa. The FSP will identify sampling locations and intensity, present field methodology and sample management procedures, and describe QA/QC protocol. It will also document the selection of new target taxa, COCs, and ecological endpoints. The FSP will be prepared consistent with Ecology SOP 5.13, and present the sampling objectives and DQOs for the ecotoxicological investigations. The FSP will be approved by EG&G and DOE before implementing Task 9.

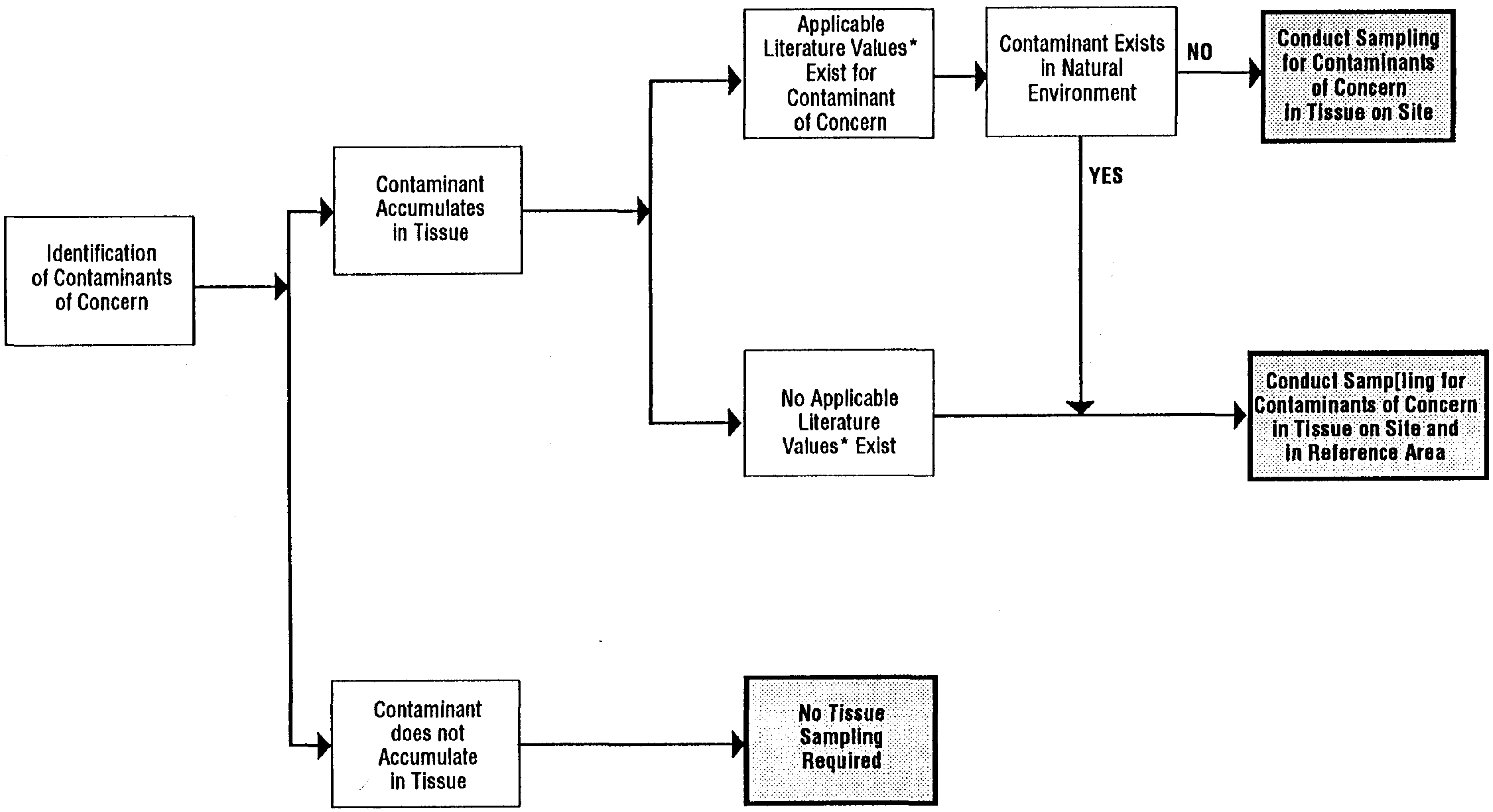
8.2.9 Task 9—Ecotoxicological Investigations

The Task 9 ecotoxicological field investigation will consist primarily of additional sampling for tissue analyses, additional measurements for biotic impact affects on ecological endpoints (that is, on populations, communities, or ecosystems), and additional toxicity testing. In addition to the quantitative investigations, qualitative surveys will be conducted to obtain seasonal information in the presence and abundance of plants and animals, and on changes in abiotic factors.

At this point in time it is difficult to determine what sampling activities will be required in addition to the Task 3 investigations that will be conducted in the spring and early summer. However, late summer and fall sampling will be necessary to obtain seasonal data and the completion—or near completion of Tasks 3, 4, and 5 will reveal data gaps. The three subtasks described below are expected for the ecotoxicological investigations.

8.2.9.1 Subtask 9.1—Conduct Comparative Ecology Studies

The comparative ecology studies; for the most part, will be an extension of the Task 3 comparative ecology studies to obtain seasonal data and improve the data base for statistical analyses of



*Literature values = Data from existing literature that can be used to determine if a given level of contaminant in tissue is toxic to the organism or harmful to consumers. Literature values may not be applicable if they are based on species that do not exist on site (e.g., trout), are based on pathways to humans, or if they are below background for the region (e.g., some metals).

Figure 8-6
Decision Process on Use of
Reference Areas for Contaminants in Ti ue

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ecological endpoints at test and reference areas. Task 3 investigations may also reveal the need for new ecological endpoints. This subtask could also include sampling for biomarkers if the Task 2 and 4 literature reviews indicate that applicable biomarkers may occur at OU 3 for the COCs or target taxa being investigated.

8.2.9.2 Subtask 9.2—Measure Bioaccumulation

Additional tissue samples will be collected during Task 9 to increase the sample sizes for assessing bioaccumulation of selected COCs. Also, if new COCs or target taxa are selected based on the results of earlier tasks, additional tissue sampling may be needed to assess the potential impacts of the new COCs or address the effects of COCs on new target taxa. The tissue sampling would be conducted using the same field methods and analytical protocol as used in Task 3. If Tasks 2 through 6 indicate that one or more of the COCs may bioaccumulate more during the late summer or fall conditions than in the spring, additional tissue samples of selected species may be obtained to assess potential seasonal differences in bioaccumulation.

8.2.9.3 Subtask 9.3—Conduct Toxicity Tests

The toxicity tests conducted during Task 3 will be limited to standard laboratory acute and chronic tests of water and sediment. If any of these tests indicate these media may be toxic to the test organisms, then additional testing will be conducted in Task 9 to evaluate the toxicity more completely and try to determine the cause of the toxicity. Also, the applicability of in-situ toxicity tests at OU 3, or toxicity tests using soil and terrestrial organisms, will be evaluated during Tasks 4 and 6. If these evaluations indicate in-situ or soil media tests are appropriate they will be planned during Task 8 and implemented in this subtask.

The revised FSP developed in Task 8 will be executed in Task 9. SOPs and analytical protocols will be closely adhered to so data obtained during Tasks 3 and 9 are directly comparable. Reference areas will be sampled in parallel with study areas. Data validation will be an integral part of the sampling conducted during this task as it was in Task 3. The results of the ecotoxicological investigations will be used to characterize risks during Task 10, and determine if ecological impacts warrant remedial action at OU 3.

8.2.10 Task 10—Risk Characterization and Report

Task 10 will include the final contaminant risk assessment, and summarization of information and production of an environmental evaluation report as part of the RFI/RI report. The EE Report will be prepared in a clear and concise manner to present study results and interpretation. All relevant data from the EE, in addition to other relevant RFI/RI data, will be integrated and evaluated in the characterization of potential environmental impacts.

8.2.10.1 Subtask 10.1—Perform Final Ecological Risk Assessment

Prior to writing the EE Report, a final ecological risk assessment verification will be conducted using the information and data collected in the field and ecotoxicological investigation in Tasks 3 through 9. This verification of the Task 6 assessment will incorporate site toxicity values and tissue concentrations from Task 9 into pathway models. Ecological endpoints, population and ecosystem effects will be characterized using a weigh of evidence approach which considers all lines of evidence in characterization. The verification process may affect the uncertainty analysis and reduce error or raise the level of confidence in the EE. Additional data needs or studies beyond the scope of the EE may be suggested.

8.2.10.2 Subtask 10.2—Characterize Risk

Information acquired during the field investigations at OU 3 (Tasks 2, 3 and 4, mentioned earlier in this section) and developed during the exposure assessment, toxicity assessment, and ecological studies (Tasks 5, 6, and 7, earlier in this section) will be used to characterize the risks posed by contaminants released from the RFP into OU 3. The evidence from these tasks that support conclusions that potential impacts on plants and animals within the offsite area are occurring or have occurred, or that no impacts are present will be evaluated. The risk characterization process will include the following:

- Comparing projected contaminant intakes to acceptable intakes

- Comparing exposure point concentrations to toxicity values in the literature, and other criteria and standards, if applicable

- Comparing ecological endpoints of plant and animal populations within OU 3 to reference populations

- Evaluating the results of direct toxicity tests and bioaccumulation studies.

The risk characterization will present risk estimates for defined exposure scenarios, in addition to summaries of the relevant biological information, identification of the assumptions used and their limitation, and a discussion of uncertainties. The characterization will address risks associated with the contaminants of concern, plutonium and some metals.

The risk posed by contaminants released from OU 3 will be assessed using one or more of six different methods of analyzing risks to the environment:

1. Comparing exposure point concentrations to published criteria and toxicity values with known adverse effects

2. Evaluating toxicity test data on laboratory organisms (such as mice or fathead minnows) to assess risks on actual populations in the reservoirs or terrestrial habitats at OU 3

3. Comparing the ecological endpoints for populations of plants or animals existing in contaminated areas to uncontaminated or "reference" areas

4. Comparing estimated intake rates and reference doses for some terrestrial species to assess acceptable and unacceptable risks

5. Evaluating bioaccumulation levels

6. Applying quantitative fault/event tree analysis.

Other methods that have been used for ecological assessment, such as ecosystem modeling, are not appropriate for use at the offsite areas, at least during this RFI/RI. These methods involve the use of computer simulation and require extensive field verification for assumptions in the modeling.

In summary, the potential risks from contaminants at OU 3 will be characterized by using several lines of evidence when possible. None of the above six approaches are appropriate for characterizing risks for all the contaminants of concern or all the target species. Also, the use of just one approach will frequently provide an incomplete evaluation of risks. Therefore, whenever possible, several lines of evidence will be used to characterize the risks at OU 3. When several line of evidence support the same conclusion, the weight of evidence will counterbalance the uncertainties inherently associated with these approaches.

8.2.10.3 Subtask 10.3—Prepare Environmental Evaluation Report

An initial draft report will be written in which the following topics will be covered report:

- Objectives
- Scope of Investigation
- Site Description
- Contaminants of Concern and Target Species
- Contaminant Sources and Releases
- Exposure Characterization
- Impact Characterization

- Remediation Criteria
- Conclusions and Limitations.

A proposed outline for the EE Report is presented in Table 8-9. An Executive Summary will present the basic information in each section of the assessment, how this information supports the characterization and the general conclusion reached in the EE.

In the EE Report, results will be presented in a clear, concise manner. The conclusions will be organized around the risks posed by contaminants from OU 3 to specific plant and animal species. Final conclusions will be based on lines of evidence from several assessment techniques. The conclusions section will include a discussion of EE objectives to determine if they were accomplished. Also, uncertainties associated with the EE will be presented, along with an evaluation of how these uncertainties influence the conclusions. The EE will determine whether OU 3 presents an unacceptable environmental risk unless remedial actions are undertaken. The criteria for determining what constitutes and unacceptable environmental risk will be developed during the EE process.

The EE Report will have four basic uses. It will be used to:

- Determine the nature and severity of the environmental risk resulting from existing contamination conditions at OU 3 without further remedial action (the "no action" alternative), and under certain future site conditions

- Provide information for comparison of alternatives and evaluation of potential environmental impacts of the remediation alternatives

- Prepare appropriate environmental documentation needed to comply with the National Environmental Policy Act (NEPA)

TABLE 8-9

PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE FOR OU 3

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 Approach and Objectives
- 1.2 Contamination
- 1.3 Scope of the Environmental Evaluation

2.0 SITE DESCRIPTION

- 2.1 Physical Environment
- 2.2 Terrestrial and Aquatic Ecosystems, Habitats
- 2.3 Contaminants of Concern
  - 2.3.1 Sources and Releases
  - 2.3.2 Criteria and Definition

3.0 CONTAMINANT RISK ASSESSMENT

- 3.1 Information and Data Base
- 3.2 Ecological Field Investigations and Sampling Results
  - 3.2.1 Toxicity Testing
  - 3.2.2 Tissue Analysis and Bioaccumulation
  - 3.2.3 Ecological Effects
- 3.3 Toxicity Assessment
- 3.4 Exposure Assessment
  - 3.4.1 Pathway Analysis
  - 3.4.2 Exposure Media
  - 3.4.3 Chemical Fate and Transport
  - 3.4.4 Exposure, Dose Analysis
- 3.5 Toxicity and Ecological Effects Characterization

4.0 RISK CHARACTERIZATION

- 4.1 Final Contaminant Risk Characterization
- 4.2 Uncertainty Analysis and Assumptions
- 4.3 Remediation Criteria
- 4.4 Summary

5.0 REFERENCES

- Determine other environmental requirements such as habitat (wetlands) protection and rare and endangered species.

The introductory sections of the EE will define the objectives and scope of the EE investigation and generally describe the physical and biological characteristics of the site. Information from this EE and prior studies, such as the OU 3 reports and previous field investigations, will be used to identify the COCs, assess the sources and fate of transport mechanisms for these contaminants, and describe the logical pathways and receptor species or communities.

Since the assessment of risk to biological receptors is largely based on the weight of the evidence supporting particular conclusions, a summary section will be included in the EE Report. This section will present the various lines of evidence supporting (or failing to support) each basic conclusion and discuss the associated uncertainties. The factors that limit or prevent development of definitive conclusions will be described and the degree of confidence in the data used will be presented.

The EE Report will be structured and written to facilitate its use by a diverse audience: technical specialists, scientists, administrators, and the general "lay" public. Portions involving technical detail, such as explanations of methodologies or fate and transport models, will be presented in appendices. An Executive Summary will be prepared to briefly present the basic information contained in the ecosystem characterization, exposure, toxicity, and risk assessment portions of the report and describe how this information supports the risk characterization conclusions. A complete list of references, including the scientific literature cited, will also be included.

Other documentation and forms related to conducting the environmental assessment will be kept as backup as required by Volume I of the SOP, (EG&G, 1991b) and other DOE or EG&G requirements.

8.2.10.4 Subtask 10.4--Develop Remediation Criteria

Remediation criteria protective of Rocky Flats biota will be developed in Task 10 on the basis of the results of the food web analyses, pathways model, and exposure assessments. Remediation criteria will be developed for contaminants for which a significant ecological impact is detected or for which that risk exists. Criteria will address remediation of the contaminant source so that remaining environmental concentrations and forms do not pose a threat to identified ecological receptors. "Acceptable" environmental concentrations will be estimated using exposure assessments to calculate contaminant concentrations in abiotic media below which the ecotoxicological effect is not expected to occur. The acceptable (no effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as appropriate for the Environmental Evaluation portion of the RFI/RI. This approach will be integrated with the Baseline Human Health Risk Assessment process and will assist in development of potential remediation criteria.

8.3 FIELD SAMPLING PLAN

This FSP describes the program for sampling biota and ecological parameters in aquatic and terrestrial ecosystems within and near OU 3 in order to assess the ecological consequences of releases of contaminants. The plan is designed to provide comprehensive data and information on biological and ecological field characteristics of the OU. The ecological field sampling program has three main objectives:

1. Characterize biological resources in order to conduct an ecological impact assessment

2. Acquire the data necessary to measure ecological effects of contaminants that cannot be assessed by the dose-response and comparison-to-criteria approaches

3. Determine if media (e.g., water and sediments) are toxic to living organisms.

The field sampling procedures have been developed following protocols recommended by the EPA (EPA 1987a, 1988a, 1989d, 1989f), the U.S. Fish and Wildlife Service (1981a, 1981b), and those currently being developed at the RFP. All ecological data and sample collection will follow the procedures provided in the Ecology SOP (Volume V) (EG&G 1991b), with appropriate site specific addenda as needed. The SOP 5.13 Development of Field Sampling Plans for biological sampling was used to develop sampling procedures. This SOP includes procedures for sampling populations or communities, collecting tissue samples, handling and preserving samples, and conducting QA/QC activities. This ecological field sampling plan will be reviewed periodically and updated as needed.

The ecological field sampling has been carefully integrated with the RFI/RI sampling for OU 3 in order to coordinate the water, sediment, and soil sampling efforts with the ecological sampling. Where possible, vegetation sampling will be located in the same areas and scheduled to coincide with soil sampling. Surface water and sediment sampling will coincide with aquatic sampling. In addition to planning sampling events during the same timeframe, the RFI/RI sampling procedures and analytical protocols for water, sediment, soil, and air samples will be planned so that the data necessary to develop and model exposure pathways during the EE will be available. The ecological field sampling at OU 3 will also be integrated with the ecological field sampling at the 903 Pad (OU 2), Walnut Creek (OU 6), and Woman Creek (OU 5) so that the data produced at these adjacent operable units are compatible. If appropriate, the OU 3 comparative ecology studies may use the same or common reference areas established on a RFP sitewide basis.

The FSP will consist of initial qualitative field surveys conducted in the spring, followed by qualitative and quantitative field sampling events in the spring-summer and the summer-fall time periods. The quantitative sampling will be done by taxonomic groups: vegetation; small mammals; wetlands; benthic macroinvertebrates; and fish. During the quantitative sampling efforts, the sampling teams will record qualitative observations to assist in interpreting the field data. The initial qualitative surveys will be scheduled to coincide with the start of the growing season of prairie vegetation. The aquatic surveys will be conducted after snowmelt and spring storms have produced several weeks of continuous flows in the major drainages.

Standard statistical methods and procedures will be used to analyze data collected in the quantitative sampling program. Where appropriate, data will be analyzed for the statistical parameters of means, variances, and standard deviation to determine precision of values. Normally distributed data will also be analyzed for variances and correlation coefficients, or regression analysis, to determine, for example, if contaminant concentration in tissue is related to media contaminant concentration. Significant differences in paired samples between locations or sampling periods will be established, such as comparisons between reference areas and the test area sample data. Sample adequacy formulae will be used to determine if the number of samples is adequate based on mean, variance, and the level of accuracy needed. Since much of the data used to characterize the biological parameters are simply descriptive, values such as the arithmetic mean, maximum, and minimum will be reported for many samples.

The following FSP is provisional and will be periodically revised as appropriate. This sampling plan is largely complete but may be modified as the EE is implemented (see Tasks 2 and 8) in order to coordinate with the OU 3 RFI/RI site characterization and sampling at other OUs, and to update the FSP as additional information is gained during the EE process. The FSP will be modified, if necessary, after COCs and target species are selected, after preliminary determination of food webs, and after contamination source-receptor pathways are completed. In addition, planning during Task 8 may include plans for additional soil or sediment sampling in study or reference areas.

8.3.1 Site Description

OU 3 is unique among OUs at the RFP in that it is located outside the RFP boundaries. The current ecology and ecotoxicological study boundaries (Figure 8-2) were set based on current information regarding the distribution of RFP related contaminants in the offsite area, on the location of creeks that drain the RFP, and on the concerns expressed by federal and state agencies and local land owners. The current OU 3 study area boundaries are Indiana Street along the west side, north to Highway 128, east to Simms Street, south to West 100th Avenue, east to the area downstream of Standley Lake Dam, south around Standley Lake, then west along the ridge south of Standley Lake to Indiana Street (Figure 8-2).

8.3.1.1 Site Uses

The area within OU 3 has had a variety of uses and disturbances: the cultivation of irrigated crops and dryland grains, rangeland grazing, and the development of canals, reservoirs, roads, and housing. Much of the area is disturbed to the point where no natural ecosystems are present, or those that are present have been modified. About 250 ac within OU 3 near Indiana Street are currently being tilled and revegetated to remediate elevated surface concentrations of radionuclides, as per negotiated settlements with landowners. There are no natural preserves, although some areas are now being maintained as open space by Jefferson County and the City of Broomfield. Prairie dog populations are expanding, affecting large areas of vegetation. Great Western Reservoir, Mower Reservoir, Standley Lake, and Walnut and Woman Creek are the principal aquatic ecosystems. Several ditches occur within OU 3 to transfer irrigation water and municipal water supplies, including the Highline and Croke Canals, Mower Ditch, Broomfield Diversion Ditch, and Church Ditch.

8.3.1.2 Reference Areas

The use of reference areas is a potential method of comparing impacted and nonimpacted areas as discussed in Subtask 1.6. Reference areas for appropriate aquatic and terrestrial ecosystems will be selected during the qualitative survey. These areas will generally be upwind of and upgradient from the RFP to avoid contamination. The number of reference areas chosen and their size will reflect the major vegetation types and habitats determined in OU 3 during the qualitative surveys. As a practical matter, generally one reference area for each major ecosystem type will be chosen. Reference areas will be chosen to distinguish the effects of contaminants from those of physical disturbance. This will be accomplished by keeping the physical characteristics of the reference areas as similar as possible to those of the OU, and controlling access and sampling disturbance. Criteria for reference area selection are discussed in Subtasks 1.4 and 2.3. If references areas have already been chosen for other OUs, they will be assessed for comparability to the ecosystems at OU 3. Differences between study and reference sites will be carefully documented.

8.3.2 Objectives

8.3.2.1 General Objectives

In general, the ecological field sampling program will provide data necessary to compare aquatic and terrestrial populations or communities at impacted and reference areas, measure toxicity directly, and measure the accumulation of contaminants in plant and animal tissue. As stated above, the field sampling program is divided into two components: qualitative surveys followed by quantitative field sampling. The objectives of the qualitative surveys are as follows:

- Acquire additional site-specific data on plants, animals, and habitat types to assist in identifying potential exposure pathways
- Acquire data needed to characterize the major ecosystem components
- Determine the presence, absence, and distribution of plant and animal receptors within OU 3
- Confirm that no threatened or endangered species, critical habitats, or state species of concern occur within OU 3
- Acquire information needed to optimize the quantitative sampling plans
- Observe and document obvious indications of contamination and, if possible, impacts on biota or habitats
- Fill gaps identified during review of existing data.

The objectives of the quantitative ecological field sampling program are as follows:

- Acquire information needed to assess seasonal changes in habitat types and document the presence and distribution of biological species

- Measure populations for composition, productivity, standing crop or biomass

- Collect quantitative data to estimate intake rates, exposures, and food chain relationships

- Measure indicators of toxicity (ecological endpoints) in populations and communities, and assess the differences between endpoints in impacted and reference areas

- Measure toxicity directly using various biomonitoring methods

- Measure accumulation of selected inorganics and radionuclides in plant and animal tissue

- Fill data gaps identified during the literature review and the qualitative field surveys.

8.3.2.2 COCs and Target Species (Receptors of Concern)

Contamination at OU 3 is primarily the result of airborne and waterborne transport of radionuclides and metals from the RFP during past operations at this facility. The preliminary list of the COCs is given in Table 8-7. This list was developed using the criteria discussed in Subtasks 1.4 and 2.3, and the site information obtained during the initial site visit and from existing literature. Based on the current knowledge of the site and the conceptual exposure model (Figure 8-3), the target species for the EE at OU 3 will probably be limited to species or taxonomic groups of terrestrial and wetland vegetation, small mammals, benthic macroninvertebrates, and fish.

8.3.2.3 Data Quality Objectives

The primary objective of the field investigations at OU 3 is to collect the data necessary to evaluate and quantify the risks to biological receptors as a result of contaminant releases from the RFP. The EE will also provide data for determining the need for remediation at OU 3, and for evaluating remedial alternatives, if necessary. The development of the DQOs for this EE is discussed in Subtask 1.3 (Subsection 8.2.1), and the general DQOs for sampling target taxa, sample management and analyses, and compiling and reporting data are presented in Subsections 8.3.3.1 and 8.3.3.2. Additional DQO details from each sampling activity will be developed after the 1992 spring qualitative surveys are complete.

8.3.3 Habitat and Taxon Specific Sampling

The major terrestrial habitat types in the study area are upland grasslands, wetlands, and some riparian shrubland and woodland. Weedy/forbs habitats are becoming established on abandoned cropland, and in areas dominated by prairie dogs. Major aquatic habitat types are open bodies of water (reservoirs) and intermittent streams. The habitat types as determined by the initial site visit are presented in Figure 8-7. The boundaries and locations of these habitats will be refined as qualitative surveys of terrestrial and aquatic ecosystems are conducted early in 1992.

8.3.3.1 Terrestrial Ecosystems and Biota

The purpose of the terrestrial field sampling program is to develop a thorough familiarization with site characteristics, sample for biotic components and measure for bioaccumulation. Qualitative survey will be followed by quantitative sampling of terrestrial ecosystems and biota that will be conducted primarily to characterize the ecosystems and measure the ecological consequences of contaminants released from the source areas.

8.3.3.1.1 **Qualitative Terrestrial Studies.** The purpose of the reconnaissance and qualitative field survey is to develop a thorough familiarization with site characteristics in order to guide the quantitative field surveys. All features of OU 3 will be covered in the reconnaissance field surveys, including topography, drainages, soils, vegetation, animals, wetlands, and the relationship of these features to land use. This FSP was based in part on information produced in the two reports on OU 3 by DOE (DOE, 1991a, 1991b). The site was visited on a initial familiarization field trip in which the major habitat types and ecosystems were observed, but no detailed sampling or field measurements were made. Qualitative surveys will follow protocol in Subsection 5.10 in the Ecology SOP.

The initial qualitative field survey will be conducted in the spring, coinciding with the start of the growing season of grassland vegetation as early in the season as possible. The surveys were designed to describe the terrestrial ecosystems within OU 3, identify the biota and habitats present, further define the conceptual model of contaminant transport or uptake by biotic and abiotic mechanisms. This survey will also be used to confirm the sampling locations, frequencies, and protocol for the quantitative sampling effort to be conducted later in the summer.

The initial qualitative survey will include locating and evaluating all sampling sites selected for quantitative sampling, including several potential reference areas. The survey will include: documenting visual observations; collecting some vegetation samples; and recording all observations in field logbooks.

The qualitative field surveys will be planned in advance to provide the following information:

- Physical description of all sampling sites
- Documentation of similarities and differences between the reference areas and on-site sampling locations

- Identification, collection, and initial inventory of plant and animal species
- Vegetation/habitat map and descriptions of principal habitats, and initial sampling of vegetation for characterization
- Description and location of critical or sensitive habitats; list of threatened or endangered species observed
- Description of the principal exposure pathways and conceptual model of principal food chain relationships
- Qualitative descriptions and some quantitative sampling of wetland and prairie grassland communities, including identification of dominant and subdominant species
- Descriptions and locations of obvious signs of impact on terrestrial vegetation or terrestrial communities
- Relative abundance of key terrestrial receptors.

The qualitative field surveys for the terrestrial ecosystems will follow an established protocol and timing. The entire area of OU 3 inside the boundary and down-slope to the east will be driven and walked to identify terrestrial communities and general ecosystem components. Information developed during the field survey will be verified using information from other past and current sampling programs on the biota in the area of OU 3. Observations will be made on species present and voucher specimens will be collected. Information will be collected on general land use patterns, distribution of plant and animal species, conditions of the land surface, soils and substrates, boundaries of plant community types and habitats, relationships to soil types, and the physical and biological condition of the vegetation and habitats. Wetlands around seeps and along drainages and possible snow accumulation areas will be located and delineated for later quantitative sampling.

All observations will be recorded in field logbooks and voucher specimens will be given a unique identification.

The physical limits of the proposed quantitative sampling locations will be determined. A reconnaissance will be conducted of the vegetation, small and large mammals, predators, birds, and signs of animals (tracks, scat, skeletons, burrows, etc.). At sampling locations close to the RFP boundaries, obvious signs of impacts or effects of contaminants will be recorded. Observations on recent biological activities that may impede or increase the movement of soil- or water-borne contaminants will be noted. In particular, a visual survey will be made for prairie dogs, ants and fossorial animals such as gopher which bring large amounts of subsurface soil to the surface where it is distributed by wind. Observations will also be made for badgers and foxes which excavate dens or dig in search of prey. All areas on OU 3 areas will then be systematically surveyed for amounts and kinds of soil and subsoil disturbances by animal activity. An intensive study of these activities will be performed in selected areas during the quantitative sampling program, if warranted.

The selection of species or ecosystem components to be collected for quantitative sampling or tissue collection will be verified. Based on information from the other sites and DOE reports, snow accumulation depressions and wetland plant communities that have developed around springs and seeps downgradient of the source areas may be sensitive indicators of contaminant migration via the groundwater pathway, or may accumulate contaminants by physical processes. Wetland plant communities are known to filter and accumulate contaminants such as radionuclides and heavy metals. These wetland areas present will be examined for evidence of contaminant accumulations. A second component that may accumulate contaminants are snow accumulation areas that may concentrate airborne particles.

Qualitative surveys for mammals, birds, and reptiles will be conducted by systematically driving and walking the area on preselected routes at appropriate times. Bird surveys will be conducted at dawn and dusk. Records will be kept of species and other features observed such as numbers, condition, habitat, and activities. Other evidence of animals or birds including burrows, scat, and nests will be recorded. Checklists will be prepared prior to the qualitative surveys of animal and plant species to record survey information.

The results of the qualitative field surveys for terrestrial ecosystems will be summarized. The specific conditions of the grassland and wetland ecosystems will be discussed as they relate to exposure pathways. Obvious indicators of stress related to contamination including pathological conditions such as necrosis, chlorosis, and stunting of vegetation will be described. Other indicators are diversity and abundance of species in impacted areas. Revisions in the quantitative sampling plan may result from the qualitative survey.

8.3.3.1.2 Quantitative Terrestrial Studies. Quantitative sampling of terrestrial ecosystems at OU 3 will be conducted primarily to complete inventory of the ecosystems for a site characterization and to measure the ecological consequences of contaminants released or resuspended from the source areas. The quantitative sampling program will include measuring biota at selected sampling stations, measuring contaminant bioaccumulation, and conducting comparative ecological studies if appropriate. The quantitative sampling will supplement qualitative survey information used for characterizing the ecosystems, identifying major plant and animal receptors, and developing exposure pathways. Qualitative observations will continue to be recorded when field biologists are conducting quantitative sampling.

The parameters chosen for quantitative sampling are determined by the needs of the ecological risk assessment. In the information to date, the principal contaminants are plutonium and americium which are generally immobile in the environment and are not bioaccumulated. At the level of contamination of soils, the uptake into terrestrial plants and animals would be below detection levels. The rationale for the choice of terrestrial organisms to sample and contaminants to measure is to demonstrate that the uptake and accumulation of known contaminants from RFP are below detection limits. For this reason a primary producer, above ground plant biomass, and a primary consumer (herbivore), a small mammal (microtine) was chosen as the most likely to shown contaminant uptake. If these two principal components of the food chain do not show measurable accumulations, hence ecological effects, then other higher components in the food chain will not be affected. The lack of effects can also be demonstrated by comparative ecology, by measuring reference areas against comparable ecosystems components in OU 3.

Field sampling operations for measuring bioaccumulation and conducting comparative ecological studies in selected species are described in the following subsections. The field procedures will be carefully integrated with similar ecological assessment field studies at OU 6 (Walnut Creek), OU 5 (Woman Creek), with the National Pollutant Discharge Elimination System (NPDES) program at the RFP which assesses water quality of plant discharges, and with routine monitoring and special sampling events conducted by the State and EMAD. Selection of sampling locations will be coordinated with other RFI/RI sampling, specifically for surface water, sediment, and surficial soil sampling locations. The planning and preparation for field sampling at OU 3 will include development of sample and waste management protocols that are integrated with, and in conformance with, sample and waste management procedures and quality assurance/quality control (QA/QC) requirements for the Environment Restoration (ER) Program.

The field sampling program for terrestrial communities is directed at sampling grassland vegetation, wetlands, and small mammal populations, at selected locations on OU 3. The area within OU 3 has a diverse pattern of semi-natural terrestrial ecosystem, development, land use, and the vegetation and associated animals due to recent and repeated surface disturbances. The stations selected for terrestrial sampling have been tentatively located as shown in Figure 8-7, and the sampling program is summarized in Tables 8-10 and 8-11. The station locations and the selection of the vegetation types to be sampled will be consistent with the results of the 1992 spring qualitative survey and will correspond to soil and surficial sampling locations as much as possible. A reference area or areas selected for comparative studies will be sampled for similar components and parameters.

Vegetation

Objectives. The grassland community at the reference and sample areas will be measured for plant species composition, cover, and productivity using standardized procedures. These

TABLE 8-10

SUMMARY OF FIELD SAMPLING ACTIVITIES FOR TERRESTRIAL BIOTA FOR OU 3

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
TERRESTRIAL BIOTA					
Qualitative Field Surveys					
B-1 Vegetation	Characterize vegetation types	Field reconnaissance for species and cover using quadrant sampling	As needed to characterize	As needed using quadrants and linear transects	Field reconnaissance and survey will be sufficient to record species composition and present conditions, and to estimate cover; identify potential hot spots, and snow accumulation areas.
B-2 Wildlife/habitat types	Characterize species and habitat type	Field reconnaissance by driving and walking transects	As needed to characterize	As needed	Records of species present and habitat types, utilization, and estimates of population densities for site characterization.
B-3 Wetlands/riparian zones	Characterize for distribution	Field reconnaissance	As needed to characterize	As needed	Field surveys will be sufficient to characterize number, size, distribution, and condition of all wetlands and riparian zones.

TABLE 8-10

SUMMARY OF FIELD SAMPLING ACTIVITIES FOR TERRESTRIAL BIOTA FOR OU 3 (Concluded)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
Quantitative Field Sampling					
B-4 Vegetation–above ground biomass	Characterize contaminant concentrations and bio-accumulation	Radionuclides on all samples	In conjunction with 1,000 meter grid for soils; nearest vegetation type to soils location; other samples in developed vegetation types or hot spots	~10 in grid using 0.25 m^2 plots; four locations in hot spots; six located snow accumulation areas	Vegetation above ground biomass sampling will determine uptake and foliar deposition of contaminants for dose response and as a transfer into food chains.
B-5 Wetlands vegetation	Characterize contaminant concentrations and bioaccumulation	Radionuclides and metals	Dependent on field surveys	Estimated at 10 general; two located in hot spots	Wetland vegetation has the potential for accumulation of contaminants through filtration and uptake.
B-6 Small mammals	Characterize bioaccumulation	Radionuclides on all samples	Dependant on field surveys	Ten located with vegetation samples	Small mammals have the potential for contaminant accumulation through ingestion of plants and soil.

TABLE 8-11

TERRESTRIAL FIELD SAMPLING PROGRAM FOR VEGETATION, SMALL MAMMALS, AND WETLANDS OPERABLE UNIT NO. 3

Component	Parameter	Sampling Period	Station (See Figure 8-7)
Grassland	Cover by species Productivity Tissue analysis	Early Summer Late Summer	15 stations; 11 colocated with soil sampling
Small Mammals	Species Density Tissue analysis	Early Summer Late Summer	To be determined; 10 stations; colocated with grassland stations
Wetlands	Species Dominance Tissue analysis	Late Summer	Approximately six locations

parameters give the best indication of the structure and function of dryland vegetation. Plant species growing on OU 3 will be noted and collected for tissue analysis. Shrub and woodland types of a size sufficient will be sampled using linear transects or a counting method for numbers and sizes of plants. The sampling protocol will follow Section 5.10 in the Ecology SOP.

Spring and late summer data will be collected, and tissues will be collected for analysis at a time to be determined later. Data collected will be used to assess the following objectives:

- Total plant cover
- Cover by perennial grasses, annual grasses, perennial forbs, and annual or biennial forbs
- Cover by individual species
- Richness (number of species)
- Production (standing biomass in grams per square meter [g/m^2] and pounds per acre [lbs/acre])
- Height (cm).

Sample Locations. The locations for sampling grassland vegetation will correspond with the soil sampling locations with additional locations based on grassland vegetation types as shown in Figure 8-7. Exact sample locations will be determined during the qualitative field surveys by inspection. Reference site sampling locations will be defined at that time if a reference site is determined to be necessary. Within the sampling area, transects for vegetative cover and clipping plots for productivity will be located close to the soil sampling points or in areas of well-developed vegetation. Quadrant locations may be rejected if they have been disturbed or are not representative of the local vegetation. Vegetation will also be sampled from sites that are known to accumulate snow, and may, therefore, have higher levels of contaminants from physical concentration.

Collection Methods. Two types of quantitative surveys will be used for cover estimates; point intercept transects for grasslands and linear transects for shrubby and woody vegetation. In the intercept transects, plant species will be recorded based the number of hits and notes made on height, condition and phenology. For productivity in grasslands, one-half square-meter plots will be clipped according to the current season's growth by species or type of species and bagged for dry weight and tissue analysis. The number of transects or quadrats for both cover and productivity will be determined by a sample adequacy formula. The sample adequacy will be determined using a formula for adequacy and the level of accuracy desired. Sample procedures will follow Subsection 5.10 in the Ecology SOP.

The transect samples will be analyzed for species composition and cover, and the frequency and dominance (importance) values derived. The sample clipped for productivity will be collected in bags, oven-dried to a constant weight, and weighed. Additional samples will be collected and analyzed for tissue concentrations of radionuclides. The grassland quadrant sample will provide species composition, cover, productivity, diversity, and structure of the terrestrial ecosystems. Tissue sample analysis will provide information on concentrations of contaminants in vegetation as an indication of bioaccumulation.

A secondary method for sampling sufficient quantities of plant material to measure plutonium uptake or foliar deposition is to mow an area of sufficient size to collect up to 5 kilograms of material.

Sampling Intensity. Grassland will be sampled during two periods for the Task 3 sampling: an early season sample during late spring-early summer and a late season sample during the late summer. Cool-weather grasses and early-season forbs will be primarily sampled during the first sampling period. Warm-season grasses and late-season forbs will be sampled during the latter period. The Task 9 sampling period, if needed, will occur immediately after Task 3 sample results are analyzed for completeness for modeling. It is critical that this occur as quickly as possible before weather makes the Task 9 sampling impossible or inaccurate, or postponed to the following growing season. Sample size will be determined at the time of sampling with species area curve plots and sample adequacy calculations. Sample frequency is dependant on the climate (temperatures and precipitation) of the year the sampling is done, therefore exact sampling dates will be determine during the sampling season.

QA/QC Sample Schedule. Quality assurance/quality control will following procedures defined in SOP 5.0. Any variance from SOP will be described and the reason explained. Quality assurance/ quality control for tissue sample collection will be accomplished by collection of collocated duplicates according to the Quality Assurance Project Plan (QAPP).

Sample Handling and Preservation. Biomass samples will be separated by species into labeled paper bags and oven-dried in the bag (104°C for 24 hours) then weighted. Clipped material will be maintained in the marked paper bags until the conclusion of the study. Samples collected for tissue analysis will follow the sample preparation and packaging specified by the laboratory protocols for the selected analytes and should be generally consistent with SOP 1.13.

Wetlands

Objectives. Wetlands, although small in size and extent, will be sampled because they are an important and productive vegetation type. The ecological endpoint of the wetland sampling is a determination of whether wetland plant tissues bioaccumulate contaminants in surface water from overflow sites, underground springs and seeps.

Sample Locations. The wetlands at OU 3 grow around the reservoirs and seeps in the drainages and ditches east and downslope of the RFP. Wetlands will be characterized for location, size and condition, and sampled in late summer for dominant species present.

Collection Methods. Samples will be taken of major wetland plant species for tissue analysis. The growing shoots will be clipped and handled in the same manner as the grassland samples.

Sampling Intensity. The wetlands will be sample once during the growing season to coincide with the greatest period of productivity, generally during late summer.

QA/QC Sample Schedule. The schedule is dependant on the conditions during the growing season and the phenology of the wetland plants.

Sample Handling and Preservation. Samples will be collected and preserved using the same protocol as the grassland vegetation.

Small Mammals

Objectives. Small mammal populations will be surveyed to determine habitat use and relative abundance. The results will be used to select species to be collected for tissue analysis. The data will be used in development of pathways models and the exposure assessment. For community evaluation, endpoints will include:

- Richness (number of species)
- Abundance (number per trapping period) by species
- Mean weight.

Small mammals, particularly microtines, will be trapped because they are primary consumers of vegetation and form the basis for the link to the higher levels in the food chain leading to top carnivores. Alternate species that may be collected for tissue analysis are prairie dogs or pocket gophers, because they live on and in the soil and may be directly exposed to contaminants.

The contaminants to be sampled in small mammals are the radionuclides that are known contaminants in OU 3 (Table 8-10). These contaminants will be indicative of the condition of this important trophic level.

Sample Locations. Sampling locations will coincide with vegetation sampling plots for tissue analysis in areas of suspected contamination and in reference areas, where appropriate. These locations may be modified, based on results of the qualitative field surveys conducted in the late spring. Systematic sampling for population densities and conditions will not conducted due to the large area involved, lack of control on offsite properties, and the diversity of the habitats. The locations of sampling sites will be chosen to represent the habitat types determined during the qualitative surveys.

Collection Methods. Small mammals will be collected using the live-trapping techniques described in SOP 5.6. Traps will be laid out in a systematic patterns to adequately sample a habitat. The traps will be run for four consecutive periods during the early evening or until an adequate number of animals is trapped. Animals trapped will be recorded for species, weight, sex, and breeding condition. Obvious signs of environmental stress will be recorded.

Tissue samples will be collected, if determined necessary, from grids corresponding to vegetation transects in areas of known contamination. To collect individuals for tissue analysis, each individual of the designated target taxon will be randomly assigned to a particular analytical suite. Collection will continue until all of the required sample quantity is obtained. If composite samples are required, each individual will be randomly assigned to a sample, and collection will continue until six samples of the appropriate quantity are obtained. If multiple trap-nights are required to obtain adequate sample quantity, individuals will be frozen as soon as possible, but within four hours of collection. Tissue sampling will occur in late summer or fall after the conclusion of the live-trapping program. Only adult males and nonlactating females mammals will be collected. Reference areas may be used in the tissue sampling section of the study, if necessary and appropriate.

Sampling Intensity. There will be two trapping periods, the first in mid-June for early season populations, and one in late August to determine changes in concentrations from the season's activities. Each sampling suite will be run for a least four consecutive nights.

QA/QC Sample Schedule. Quality assurance/quality control will following procedures defined in SOP 5.0. Any variance from SOP will be described and the reason explained. Special attention must be paid to minimize chance of harm to the animals not intended for tissue analysis and to avoid injury to the workers from animal bites or scratches.

Sample Handling and Preservation. Animals collected for tissue analysis will be sacrificed by placing into a sealed container with cotton saturated in Metafane, inducing hypothermia, or cervical separation. The dead animal will be placed in a glass sample container in a cooler with Blue or dry ice for up to 4 hours. After 4 hours, the samples must be shipped to the analytical laboratory or place in a freezer overnight or until shipped. Labeling, handling, and shipping of small mammals for laboratory analysis should be generally consistent with SOP 1.13. Samples collected for tissue analysis must follow the sample preparation and packaging specified by the laboratory protocols for the selected analytes. Animals selected for organ analysis will be dissected prior to tissue analysis.

8.3.3.1.3 Terrestrial Sampling Matrix. A preliminary activity summary has been constructed in Table 8-10 that contains purposes (tissue, quantitative or qualitative community analysis), analyses, locations and numbers of samples, and a rationale for each taxon. A more complete table will be constructed after the sampling schemes is fully determined. A preliminary matrix has been developed and is presented in Table 8-12 for sampling handling techniques.

8.3.3.2 Aquatic Ecosystems and Biota

The aquatic ecology sampling program will have two major objectives: (1) Characterize aquatic communities and couple this information with soil, surface water, and sediment data to conduct risk assessment based on the dose-response and comparison to criteria approaches, and (2) acquire the data necessary to measure ecological effects of contaminants that cannot be assessed by the dose-response and comparison-to-criteria approaches. In general, the aquatic sampling program will provide data necessary to compare aquatic communities at impacted and reference areas, to

TABLE 8-12

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size ++
SAMPLES FOR METALS ANALYSES				
Benthic Macroinvertebrates, Fish				
Metals Determined by ICP	6 months	Freeze and ship with dry ice	Plastic	25 g
Metals Determined by GFAA		Freeze and ship with dry ice	Plastic	25 g
Hexavalent Chromium		Freeze and ship with dry ice	Plastic	25 g
Mercury		Freeze and ship with dry ice	Plastic	5 g
SAMPLES FOR RADIONUCLIDE ANALYSES				
Terrestrial Vegetation				
Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 months	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	100 g
Americium-241				
Small Mammals				
Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 months	Freeze and ship with dry ice	Glass containers or plastic bags	28 to 85 g
Periphyton, Benthic Macroinvertebrates, Fish				
Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 months	Freeze and ship with dry ice	Plastic	100 g

Notes: ++ = Sample Size may vary with specific laboratory requirements.
**ICP = Inductively Coupled Argon Plasma Emission Spectroscopy.
+GFAA = Graphite Furnace Atomic Absorption Spectroscopy.

measure toxicity directly, and to measure bioaccumulation of selected contaminants in benthic macroinvertebrates and fish.

Sampling of aquatic biota will be scheduled along with surface water and sediment sampling so both the abiotic and biotic components of the sampling locations can be described. Also, sample methods and protocols used at the offsite OU 3 will be similar to those used at the onsite OU 5 (Woman Creek) and OU 6 (Walnut Creek) to maintain continuity between the studies on these two watersheds.

As described in Subsections 8.2.3 and 8.2.9, the aquatic sampling program will be divided into a qualitative field survey in the early spring, followed by quantitative sampling events, performed by taxonomic group, in the spring/summer and summer/fall time periods. In addition, the qualitative survey work will be repeated during the quantitative sampling events to increase the overall data base and supply seasonal biological data.

8.3.3.2.1 **Qualitative Aquatic Studies.** The initial qualitative field survey will be conducted in the spring of 1992 to supplement data obtained during the October 1991 initial site visit. These data will be used to identify aquatic biota and habitats, to characterize aquatic communities, to select a reference site, and to acquire data to further define the conceptual model of contaminant transport to aquatic receptors. The 1991 initial site visit was used to confirm the sampling locations and protocol for the quantitative sampling efforts. The 1992 qualitative surveys will be conducted along Woman Creek, Walnut Creek, and Mower Reservoir Ditch above and below the reservoirs to obtain seasonal data. Wetlands adjacent to the creeks will also be included. Sections of Rock Creek and/or the upper end of Woman Creek that are physically and ecologically similar to the OU 3 sampling areas will be surveyed during the spring, when water is present, to identify appropriate reference stations for the quantitative sampling on intermittent creeks. A small reservoir reference location will be identified to serve as a reference comparable to Mower Reservoir. Qualitative surveys will also search for seepage areas where groundwater may be entering the surface water system. During the initial site visit in October 1991, the area was very dry.

The qualitative survey of the reservoirs will be limited to sampling a few shoreline areas, especially where creeks flow into the reservoirs. Shoreline profiles and near-shore substrates will be described and areas of aquatic vegetation, if any, will be located.

The physical characteristics of stream sections (including the Broomfield Diversion Ditch) and ponds will be documented in the field logbook and on field survey maps during the 1992 qualitative surveys, similar to the 1991 initial site visit. Descriptive parameters such as stream width and depth, water velocity, bottom substrate, bank vegetation, proportion of undercut banks, and channel morphology will be recorded. In situ measurements of water temperature, specific conductivity, and pH will be taken with field instruments along the creeks and at seeps to document potential contaminant and/or groundwater inflow. Measurements will be taken above and below locations where surface water enters the creek, and above and below locations where there are indications of possible groundwater inflow (e.g., a change in turbidity) or environmental stress (e.g., an increase in filamentous algae). Since the creeks were dry during the 1991 initial site visit, the descriptive information described above could not be collected at that time.

The biological characteristics of stream sections, ponds, and seeps will be described using three techniques:

1. Qualitative observations of filamentous algae, slimes, aquatic macrophytes, and vertebrate and invertebrate animals

2. Qualitative sampling of fish with short seines and dip nets

3. Sampling of benthic macroinvertebrates utilizing the Rapid Bioassessment Protocols (RBP I) developed by the EPA (1989b) for cost-effective assessments of logic systems.

Fish collected by seines and dip nets will be identified, measured (total length), and released. Abnormalities such as fin rot, lesions, and external parasites will be recorded.

The RBP I reconnaissance assessment technique for benthic macroinvertebrate communities will be used to describe the communities in Mower Reservoir and creek stations if adequate benthic populations are present. The RBP I method focuses on qualitative sampling of benthos, supplemented by a preliminary examination of other aquatic biota such as periphyton, macrophytes, fish, and slimes. Standard field data sheets will be used to record the relative abundance of macroinvertebrate orders (families for *Megaloptera* and *Diptera*); occurrence of periphyton, algae, and aquatic macrophytes (plants); abundance of fish by species; and water quality measurements.

The occurrence of potential contamination along Woman and Walnut Creeks and the Smart Ditch within OU 3 will be defined based on results of field water quality measurements, observations of obvious contaminant impacts such as stressed vegetation or absence of aquatic organisms, and biological indicators. Some examples of biological indicators include changes in species diversity, absence of pollution-sensitive taxa or dominance of pollution-tolerant taxa, and abundance of filamentous algae.

8.3.3.2.2 Quantitative Aquatic Studies. Quantitative sampling of aquatic communities at OU 3 will be conducted primarily to characterize benthic macroinvertebrates, and fish populations at impacted and reference (nonimpacted) locations; to measure contaminant bioaccumulation in benthic macroinvertebrates and fish, and to determine if creek and reservoir water at selected locations is toxic to fathead minnows and *Ceriodaphnia*. The quantitative field sampling program will be carefully integrated with similar ecological assessment field programs at OU 5 and OU 6, with the ongoing National Pollutant Discharge Elimination System (NPDES) monitoring program that assesses water quality of plant discharges, and with routine monitoring and special sampling events conducted by the RFP Environmental Monitoring and Assessment Division (EMAD). The sampling procedures will follow, where appropriate, the Volume V Ecology SOP for sampling periphyton, benthic macroinvertebrates, and fish (EG&G, 1991b).

Sampling of the periphyton community will be limited to qualitative studies to characterize the types and relative abundance of periphyton types. No quantitative analyses are planned. Periphyton communities are poorly developed in the creeks because they are dry much of the year. Quantitative sampling in the creeks would likely reflect the influence of the dry seasons much more than any potential impact form RFP contaminants. The periphyton community in the reservoirs is expected to be limited because the lake bottoms are primarily fine sands and silt. Also, the reservoir periphyton community is influenced by the water quality in the reservoir, and the major source of the water is not the RFP. Periphyton in the lake will be sampled using artificial substrates and the analyses will be limited to measures of colonization rate and a qualitative characterization of the types and relative abundance of periphyton groups present.

Zooplankton and phytoplankton communities will not be sampled at OU 3. These communities are not expected to be present in the ephemeral creeks in the area. Zooplankton and phytoplankton communities should be well developed in the reservoirs, but these communities are expected to respond primarily to natural variations in temperature, turbidity, nutrient cycling, etc., rather than to potential contaminants from the RFP. This is expected because: (1) over 90 percent of the water in Great Western Reservoir and Standley Lake comes form the Clear Creek watershed via canals rather than from areas draining the RFP; (2) the water quality data from Woman Creek and Walnut Creek stations along the downgradient boundary of the RFP (the upgradient boundary of OU 3) indicates that the water in these creeks over the last few years has been of relatively good quality (EG&G, 1991e; Subsection 6.2 of this RFI/RI Work Plan); (3) phytoplankton and zooplankton have relatively short life cycles and high reproductive potentials and thus are capable of rebounding quickly from natural or unnatural stresses; and (4) recent studies of phytoplankton and zooplankton populations in Standley Lake indicate that the population dynamics are probably controlled by factors other than contaminants from the RFP.

Field sampling procedures for aquatic ecology sampling are described in the following subsections. The sampling locations are summarized in Table 8-13 and shown in Figure 8-8. These locations may be modified slightly based on the qualitative survey results scheduled for spring 1992. As indicated in Table 8-13, the most upgradient aquatic ecology sampling stations on Woman Creek, Mower Ditch, and Walnut Creek for OU 3 are the same stations used for the most downgradient stations in OU 5 and OU 6. If possible, these three stations will be sampled so that the data are available for all three OUs without duplicating field effort.

The main objectives of the quantitative aquatic sampling program are:

- Document the distribution and seasonal abundance of periphyton, benthos, and fish
- Collect data to define contaminant pathways to aquatic receptors
- Measure indicators of impact (ecological endpoints) in aquatic populations at impacted and reference locations
- Measure toxicity of surface waters to fathead minnows and *Ceriodaphina*
- Measure bioaccumulation of selected contaminants in benthic macroinvertebrates and fish.

Periphyton

Objectives. Periphyton communities in OU 3 creeks are expected to be poorly developed and influenced by the ephemeral nature of the creeks. Water may be present for only 2 to 4 months during the year. Therefore, only qualitative descriptions of creek periphyton communities will be obtained. Periphyton communities in the three reservoirs will be compared to one another and to periphyton communities in a reference reservoir to see if the water quality in potentially impacted reservoirs influence colonization of periphyton or artificial substrates.

TABLE 8-13

SAMPLING STATIONS AND SAMPLE TYPES FOR AQUATIC ECOLOGY SAMPLING

Drainage or Reservoir	Station No.	Periphyton Qual.[a]	Periphyton Quant.[b]	Benthic Invertebrates Quant.[b]	Benthic Invertebrates Tissue[c]	Invertebrates and Fish Toxicity[d]	Fish Qual.[a]	Fish Quant.[b]	Fish Tissue[c]	Sample Station Descriptions
CREEK STATIONS										
Walnut	WN-1[e]	X		X	X	X	X			Walnut Creek, west of Indiana
	WN-2			X						Broomfield Diversion Ditch
	WN-3	X		X	X	X	X			Walnut Creek downstream of Great Western
Woman	WO-1[e]	X		X	X	X	X			Woman Creek, west of Indiana
	WO-2	X		X	X	X	X			Woman Creek just upstream of Standley Lake
	WO-3			X			X			Big Dry Creek downstream of Standley Lake
	WO-4[e]	X		X		X	X			Mower Ditch, west of Indiana
RESERVOIRS										
Great Western	WN-11		X	X	X			X	X	Near Walnut Creek inlet
	WN-12		X	X	X			X		Southwest Bay area
	WN-13			X				X	X	Deepest part of reservoir
Mower	WO-11		X	X	X	X		X	X	Near Mower Ditch inlet
	WO-12		X	X				X		South Shore area
	WO-13		X	X	X	X		X	X	East Shore area

TABLE 8-13

SAMPLING STATIONS AND SAMPLE TYPES FOR AQUATIC ECOLOGY SAMPLING (Concluded)

Drainage or Reservoir	Station No.	Periphyton		Benthic Invertebrates		Invertebrates and Fish	Fish			Sample Station Descriptions
		Qual.[a]	Quant.[b]	Quant.[b]	Tissue[c]	Toxicity[d]	Qual.[a]	Quant.[b]	Tissue[c]	
Standley	WO-14		X	X	X			X	X	Near Woman Creek inlet
	WO-15		X	X	X			X	X	South Shore area
	WO-16			X				X		Deepest portion of the lake
	WO-17		X	X				X		Southeast shore area
Reference	R-1		X	X	X			X	X	
	R-2		X	X	X			X	X	

[a]Qualitative samples.
[b]Quantitative samples.
[c]Tissue samples analyzed for bioaccumulation.
[d]Water samples for Fathead Minnow and Ceriodaphnia toxicity tests.
[e]Stations WN-1, WO-1, and WO-4 are the same as the most downstream stations for OU 5 and OU 6. If possible, these stations will be sampled for all three operable units at the same time.

Sample Locations. Periphyton communities will be qualitatively evaluated at six creek stations and quantitatively assessed at eight OU 3 reservoir locations and at two reference stations (Table 8-13).

Collection Methods. The following collection methods will be used to obtain samples.

1. **Qualitative Creek Samples.** Qualitative periphyton samples will be collected by scraping these aquatic organisms off hard natural substrates, using equivalent surface areas and similar substrates at the different locations as much as possible. Water quality data such as temperature, specific conductivity, and pH will be collected as per SOP No. 4.2. Samples may also be collected at seep areas if there is enough water to support periphyton growth.

   Periphyton samples will be scraped from approximately 2 square in of substrate, transferred to a pre-labeled sample vial with distilled water, and preserved. The surface area scraped will be measured and recorded. Flow conditions and other physical and biological characteristics of the sampling location will be documented in the field log.

   Periphyton samples will be analyzed for relative abundance of major taxa (generally Divisions) and proportions of pollution-sensitive and pollution-tolerant taxa. Qualitative estimates of total periphyton abundance will be noted in the field log.

   Since total mass of periphyton samples at each station is expected to be low, these samples will not be analyzed for contaminants. Potential for bioaccumulation of contaminants will be investigated using benthic macroinvertebrates and fish.

2. **Quantitative Reservoir Samples.** Periphyton samples in Great Western Reservoir, Mower Reservoir, Standley Lake, and a reference reservoir will be collected using artificial substrate samplers as described in Ecology SOP 5.1. The samplers will be

established at two or three locations in each reservoir in late spring or summer for a 20-day period. The periphyton samplers will be placed at nearshore locations, on an anchor and float assembly to maintain the samples at a set distance below the water surface.

The artificial substrate samplers will be set and retrieved according to the protocol in SOP 5.1. They will be checked periodically and replaced if necessary. Water quality data and the physical characteristics of the sample site will be recorded when the samplers are set and retrieved. These quantitative periphyton samples will be analyzed for biomass, algal density, and taxonomic identification.

Sampling Intensity. Qualitative creek periphyton samples will be collected at six creek stations in the spring. Seasonal sampling will not be conducted because the creeks will be dry during the late summer and fall. Periphyton samples will be scraped from approximately 2 square in. of substrate at each stations.

Quantitative samples will be collected from two or three nearshore locations at each reservoir (Figure 8-8) during late spring or summer. The artificial substrate samplers will be prepared as per SOP 5.1 and sufficient slides will be used to provide biomass samples and taxonomic samples. Extra slides will routinely be used to compensate for potential breakage.

QA/QC Sample Schedule. No QA/QC samples are planned for the qualitative sampling in OU 3 creeks. For quantitative sampling in the reservoirs, collocated samplers will be established at one location in Mower Reservoir and in the reference reservoir for QA/QC. Appropriate laboratory duplicate samples will also be analyzed.

Sample Handling and Preservation. The periphyton samples will be collected as per SOP 5.1. Samples for taxonomic identification will be placed in prelabeled bottles and preserved in 5 percent neutral formalin. Biomass slides will be placed in separate prelabeled bottles and preserved in

5 percent formalin. All samples will be placed in a cooler, then returned to the lab and stored at 10°C.

Benthic Macroinvertebrates

Objectives. Benthic macroinvertebrates are the most common fauna used in ecological assessments of contaminant releases or pollution discharges. They are defined as the aquatic invertebrates that are large enough to be seen without magnification and capable of being retained by a U.S. Standard No. 30 sieve (0.595 mm openings).

Benthic macroinvertebrate samples will be analyzed to characterize the benthic community at each station and, subsequently, used to compare ecological endpoints at impacted and reference locations. The potential for contaminants to accumulate in living organisms and be transferred through the food chain will also be investigated using benthic organisms.

Sample Locations. Benthic macroinvertebrates will be collected at all eight creek stations, one reference station, ten reservoir stations and, potentially, two seep stations (Table 8-13 and Figure 8-8).

Collection Methods. The flow conditions and other physical and biological characteristics of the sampling station will be documented in the field log. Field instruments will be used to collect basic water quality data. Qualitative statements regarding the occurrence of periphyton, algae, amphibians, and fish will be recorded. All samples will be numbered and labeled as they are collected as per SOP No. 1.13.

The benthic communities in the creeks will be sampled following high flow conditions in the spring. In shallow flowing creek stations benthic samples will be collected using a 1-square ft Surber Sampler with 352 micrometer mesh net. Triplicate samples will be collected within a 25-m creek segment, as per SOP No. 5.2, moving upstream as replicate samples are taken. Each replicate sample will be transferred directly into a separate sample container, preserved in 70 percent ethanol, and labeled as per SOP No. 1.13. At reservoir stations, triplicate samples will be taken with an Ekman or Ponar Grab. These rope-suspended samplers are triggered with a messenger or close when they hit bottom, and are suited for sampling the mud and fine gravel substrates expected at these stations. Each triplicate sample will be transferred from the sampler directly to a field wash bucket with a No. 30 sieve mesh (or smaller), washed thoroughly, transferred to a sample container, and preserved. Large rocks and twigs can be discarded after organisms are hand-picked or washed into the bucket with a water spray.

At stations where additional biomass is needed for contaminant analysis samples (see Table 8-16), additional macroinvertebrates will be collected with dip nets, kick nets, or the Surber, Ponar, or Ekman sampler. Sampling will continue until sufficient biomass of some of the dominant species are obtained. These samples will be washed in the field, placed in sample containers and kept on ice.

Benthic macroinvertebrates will be collected from all aquatic sampling stations (Table 8-13). In cases where the habitat does not allow quantitative sampling, qualitative samples will be collected with dip nets and by grab samples of substrate and coarse particulate organic matter (CPOM; for example, leaves, twigs, and plant debris).

Benthic macroinvertebrate samples at each station will be analyzed for genera present, species diversity, total number of organisms by taxa, and the proportion of pollution-tolerant or pollution-sensitive taxa. The relative abundance of scaper, filter collector, and shredder functional groups will also be determined (EPA, 1989b). The data from quantitative samples will be used to determine macroinvertebrate density (standing crop); taxa richness; species diversity; ratio of scraper, filter collector, and shredder functional feeding groups; ratio of pollution-tolerant and pollution-sensitive taxa; and community similarity indices.

Sampling Intensity. Benthic macroinvertebrate samples at the eight creek stations will be sampled during the spring, after the creeks have had relatively consistent flows for 2 to 4 weeks (Table 8-13).

Triplicate samples will be taken at each sample location, as described in the preceding subsection. Seasonal samples will not be taken in the creeks because they are expected to be dry in the summer and fall.

Benthic samples from the three OU 3 reservoirs and the reference reservoir will be sampled in the spring and late summer. Samples will be collected at three stations at Mower and Great Western Reservoir, four stations at Standley Lake, and two or three stations at the reference reservoir (Table 8-13, Figure 8-8).

QA/QC Sampling Schedule. Triplicate samples will be collected at each station. Each replicate sample collected with a Surber sampler will be transferred directly into a separate sample container, preserved in 70 percent ethanol, and labeled as per SOP No. 1.13. Each triplicate sample collected with an Ekman or Ponar Grab will be transferred from the sampler directly to a field wash bucket with a No. 30 sieve mesh (or smaller), washed thoroughly, transferred to a sample container, and preserved. Six replicate samples will be taken at one creek station and two reservoir stations during the spring sampling for QA/QC and check the adequacy of triplicate samples.

Sample Handling and Preservation. Decontamination will be performed before and after all sampling and data collection activities, as described in SOP No. 1.3, General Equipment Decontamination; SOP No. 1.6, Handling of Personal Protective Equipment; SOP No. 1.7, Handling of Decontamination Water and Wash Water; and SOP No. 1.9, Handling of Residual Core and Laboratory Samples.

Benthic macroinvertebrate samples for taxonomic identification will be processed in the laboratory by rinsing the sample in fresh water (U.S. Standard No. 60-mesh screen) and transferring the sample to a shallow white tray. Benthic organisms will be separated from the debris with forceps, using a table-mounted magnifier, and placed into sample vials of 70 percent ethanol. The samples will be analyzed by identifying the organisms to genus (with some exceptions such as chironomids) and counting the number of individuals in each taxon. Identification and enumeration will be made using dissecting microscopes.

Benthic macroinvertebrate samples for tissue analysis will be rinsed in the field and kept in freshwater in an ice cooler until they are returned to the laboratory. The samples will be sorted in the laboratory to obtain suitable quantities of selected inset orders, and the samples will be frozen.

Fish

Objectives. The purpose of the fish investigations is to evaluate fish communities in the three OU 3 reservoirs and at a reference location to determine if contaminants are bioaccumulating in fish tissues to the extent that they pose a hazard to the fish itself, predators, or human consumers. The fish populations in the three OU 3 reservoirs and the reference reservoir will be characterized to determine relative abundance of species, food web relationships, and the potential value of the fish populations for recreation. Fish populations in the creeks will be sampled only qualitatively because of the ephemeral nature of the creeks. No resident fish populations are expected at the creek sampling locations (Figure 8-8), except at Big Dry Creek below Standley lake (Station WO-3). At this location, the fish community will be influenced more by Standley Lake releases, predominately water from sources not influenced by the RFP. Creek and reservoir water will be collected from fish sampling locations to determine if these waters are toxic to fathead minnows.

Sampling Locations. Fish communities will be sampled seven creek stations, ten reservoir stations, and at the reference reservoir (Table 8-13). The Broomfield Diversion will not be sampled because this water body is frequently dry and is not a natural creek. The sample stations for fisheries work will be the same 10- to 25-meter creek segments, or shoreline and deep areas in reservoirs, used for benthic sampling.

Collection Methods. Fish will be collected by electrofishing or seining similar-sized creek segments (SOP No. 5.4) and reservoir shoreline areas, and by setting gill nets at reservoir stations. All fish will be identified and counted, and the physical characteristics of each sampling location will be documented to assess the influence of physical features on fishing success and habitat. Water quality data will be taken according to SOP No. 4.2. Fish sampling, where appropriate, will follow SOP No. 5.4. The physical characteristics of each sampling station will be described in the field log, and conditions which may influence catch success will be recorded. Basic water quality measurements will be taken with field instruments at each sampling station.

All fish will be identified, counted, and measured, and dominant species will also be weighed. The fisheries data will be analyzed for relative abundance, catch-per-unit-effort statistics, and the relative proportions of herbivorous, carnivorous, or omnivorous species. Scale samples may be collected from the most common species to determine growth rates, age classes, and mortality.

Fish will be collected from all stations during the spring-early summer period and at the reservoir stations again in summer-early fall. All fish will be released back to the reservoir, except for a limited number of reference specimens, small fish that cannot be identified in the field, and individuals collected for tissue analysis. Precautions will be taken so that the sampling effort itself does not produce an impact on fish populations.

Collecting fish with backpack and boat-mounted electrofishing equipment will follow SOP No. 5.4 and field data will be recorded on the standard SOP forms (e.g., Form 5.4B, etc.). A standard sampling time will be used at creek and lake stations to maintain comparability between stations.

The shallow shoreline stations at the three reservoirs will be sampled by electrofishing, and the deep and shallow reservoir stations will be sampled by gill nets. The gill nets will be set on the bottom using procedures similar to CDH's fisheries studies on Standley Lake (CDH, 1990c). Fish will be removed at 4- to 12-hour intervals, depending on catch rates. Sampling details for shoreline electrofishing and gill netting are given in the SOP Procedure Change Notice in Subsection 11.3 of this RFI/RI work plan.

If possible, minnows and/or sunfish will be collected for tissue analysis at all stations. In the reservoirs, sport fish such as walleye, smallmouth bass, and channel catfish will be collected, in addition to minnows and sunfish, to determine if bioaccumulation is occurring, and to provide data for the human risk assessment. Large fish of other species, such as bullheads, will be kept if more biomass is needed for analysis.

Sampling Intensity. Qualitative fish sampling will be conducted at seven creek stations in the spring (Table 8-13). The creeks are expected to be dry in the summer and fall. Fish will be collected from a 10 to 25 meter creek segment. Quantitative fish sampling in the reservoirs will be conducted at three or four stations in each of the OU 3 reservoirs and at two to four stations in the reference reservoir. The reservoirs will be sampled in the spring-summer and again in late summer-fall (Table 8-13, Figure 8-8). Fish will be collected by electrofishing all shoreline stations and by gilnetting both shoreline and deep reservoir stations.

QA/QC Sample Schedule. No QA/QC samples are planned for the qualitative creek sampling or for collecting the standard ecological data on fish populations (identification, measurement, etc). An experienced fisheries biologist will lead the field team and fish not identified in the field will be returned to the laboratory where identification can be confirmed.

For fish tissue analysis, duplicate samples will be taken at Mower Reservoir and at the reference reservoir. Also, as a normal processing routine, right and left fillets from each fish will be handled separately so these can be submitted to the laboratory as duplicates, composited in different combinations depending upon catch success so adequate tissue mass is available, or prepared as separate samples for two laboratories (inorganic analysis and radionuclide analyses). One or two species of nonsport fish will also be collected for whole-body analyses. Liver samples will be collected from individuals of two fish species to determine if COCs accumulate more in liver tissue than in muscle tissue.

Sample Handling and Preservation. Fish kept for identification or reference will be preserved in 70 percent ethanol or 10 percent formalin, and fish kept for tissue analysis will be put on ice. Fish samples will be processed immediately. All fish will be identified, counted, and measured (total length to the nearest mm) in the field. Dominant species will also be weighed. Most fish will be released back to the creek or reservoir. Data will be recorded on standard field data sheets. Small individuals may be kept for identification in the laboratory.

Fish retained for tissue analysis will be kept on ice in the field after the initial processing, and transferred to cold storage in the laboratory as soon as practical. These fish will be processed in the laboratory within 24 hours. Sport fish species will be filleted as the normal processing technique, plus some individuals of the most common sport species will be prepared as whole body samples. Tissue samples will be wrapped in plastic or aluminum foil, labeled, and frozen. The samples will be maintained at a temperature near or below 0°F until they are shipped to the laboratory. Samples will be shipped on dry ice.

8.3.3.2.3 Aquatic Sampling Matrix. Table 8-13 summarizes the sampling locations and frequencies for aquatics. This table shows the sample stations, the aquatic communities that will be sampled at each station, and where tissue samples for bioaccumulation and water samples for toxicity tests will be collected. Table 8-14 summarizes the entire aquatics program by presenting the purpose, types of analyses, and rationale for sampling the aquatic communities; periphyton, benthic macroinvertebrates, and fish.

8.4 SCHEDULE

An approximate schedule for conducting and completing the work outlined in this EEWP is presented in Figure 8-9. This schedule is also integrated with the flow diagram presented in Figure 8-1 on the interrelationship of the tasks and subtasks. Decision points in this schedule for the timing of, and necessity for, a task have not been determined. However, the process for these decisions is included in the work plan.

Seasonal changes and weather patterns profoundly affect the required timing and results of ecological field sampling. The general timing of field activities will be subject to change in relationship to the seasons. The exact timing of the field sampling activities are dependent on rainfall and temperature during the growing season and the preceding winter's precipitation. To the extent possible, this timing will be adjusted to take into account these weather related factors.

TABLE 8-14

SUMMARY OF FIELD SAMPLING ACTIVITIES FOR OU 3 AQUATIC BIOTA

Data Need Addressed[1] / Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed
AQUATIC BIOTA						
Qualitative Field Surveys						
AQ-1 Benthic Macro-invertebrates	Determine predominant invertebrates, characterize habitats, select reference stations, observe obvious impacts, assess proposed sampling methods	Field identification of benthos, relative abundance, spatial distribution of major types. Record habitat characteristics.	Woman Creek Walnut Creek Reservoirs Wetlands and seeps	As needed to sample major habitat types	RFP contaminants have been found in creeks and reservoirs. Benthic macroinvertebrates are good indicators of water and sediment quality.	13
AQ-2 Periphyton	Evaluate abundance, assess proposed sampling methods, record available substrates	Record relative abundance, periphyton types, and available substrates	Woman Creek Walnut Creek Wetlands Reservoir shoreline	As needed to sample major habitat types	Abundance of these primary producers may indicate water quality and influence abundance of aquatic animals.	13
AQ-3 Fish	Determine predominant species, characterize habitats, observe spatial distribution, select reference stations, assess proposed sampling methods	Identify and measure commons species, count fish present, record abnormalities and external parasites.	Woman Creek Walnut Creek Reservoirs	As needed to sample major habitat types	Abundance, spatial distribution and condition may indicate impacts. Determine which species to use for bioaccumulation.	13

TABLE 8-14

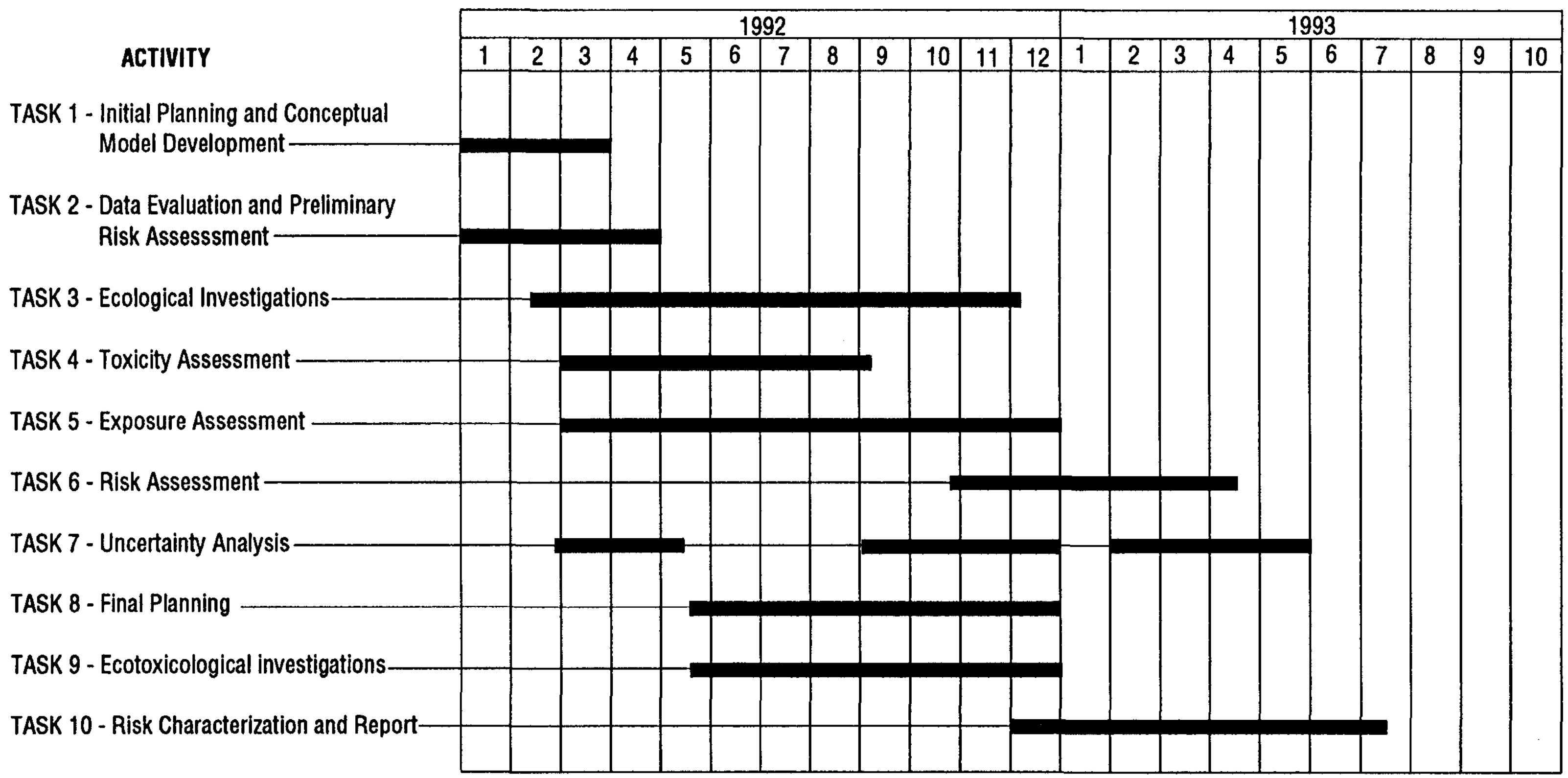
SUMMARY OF FIELD SAMPLING ACTIVITIES FOR OU 3 AQUATIC BIOTA (Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed
Quantitative Sampling						
AQ-4 Benthic Macroinvertebrates	• Compare benthic communities in OU 3 Creeks/ Lakes with onsite RFP locations and reference area • Determine if benthic organisms are accumulating contaminants	Metals Radionuclides Numbers of organisms per taxa. trophic types	• Walnut Creek above and below Great Western Reservoir • Woman Creek above and below Standley Lake and Smart and Mower Ditch above Standley Lake • Ditch above Mower Reservoir • Reservoirs and Lake	3–Walnut Creek 3–Great Western Reservoir 5–Woman Creek 4–Standley Lake 1–Mower Ditch 3–Mower Reservoir 2–To be Determined	• Assess potential impact of contaminants on creeks and reservoirs. • Characterize benthic populations in creeks and reservoirs. • Compare populations in impacted and unimpacted areas. • Determine if bioaccumulation of contaminants has occurred. • Analytical parameters target the contaminants most likely to bioaccumulate.	13
AQ-5 Periphyton	• Characterize periphyton communities in OU 3 creeks and reservoirs. Determine colonization rates in reservoirs	Number of organisms per class	• Walnut Creek above and below Great Western Reservoir • Woman Creek above Standley Lake • Mower Ditch and Smart Ditch above reservoirs	2–Walnut Creek 2–Great Western Reservoir 2–Woman Creek 3–Standley Lake 2–Mower and Smart Ditch 3–Mower Reservoir 2–To be Determined	• Characterize periphyton communities in creeks and reservoirs. • Compare populations in impacted and unimpacted areas.	13

TABLE 8-14

SUMMARY OF FIELD SAMPLING ACTIVITIES FOR OU 3 AQUATIC BIOTA (Concluded)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale	Conceptual Model Pathway Addressed
AQ-7 Fish **AQ-6**	• Characterize fish communities in Walnut and Woman Creeks and Standley Lake, Great Western, and Mower Reservoirs. Compare with onsite RFP locations and reference areas. • Determine if fish are accumulating contaminants. • Determine if water at selected locations is toxic to fish.	• Number of fish by species; lengths and weights of individuals • Identify, measure, count, and weigh - Metals - Radionuclides • Standard acute and chronic toxicity tests	• Walnut Creek above and below Great Western Reservoir, qualitative only • Woman Creek above and below Standley Lake, qualitative only • Mower Ditch and Smart Ditch above reservoirs, qualitative only • Great Western and Mower Reservoirs and Standley Lake	2–Walnut Creek 3–Great Western Reservoir 3–Woman Creek 3–Mower Reservoir 2–Mower and Smart Ditch 4–Standley Lake	• Characterize fish communities in creeks and reservoirs. • Compare fish communities in OU 3 reservoirs with reference locations • Determine if bioaccumulation of contaminants has occurred. • Determine toxicity of water • Determine if contaminants and/or environmental stress have caused increase in parasites or deformities	13



DRAWN BY	Douville 02/14/92	CHECKED BY	APPROVED BY	2-17-92 2-19-92	DRAWING NUMBER	RF1059

Figure 8-9
Proposed Schedule for the Environmental Evaluation at Operable Unit 3

9.0 SCHEDULE

A conceptual schedule for conducting the OU 3 RFI/RI is summarized in Figure 9-1. The source of the RFI/RI duration is from the IAG. The actual due dates for the RFI/RI Reports have been revised from those presented in the IAG. EPA has approved these schedule modifications. According to the schedule, approximately 2 years and 1 month will elapse from the time this work plan is finalized until the RFI/RI Report is issued.

DRAWN BY	Douville	CHECKED BY			DRAWING NUMBER	RF1058
	02/14/92	APPROVED BY				

ACTIVITY	DATES START	DATES FINISH
TASK 1 - Project Planning	3/1/92	6/30/94
TASK 2 - Community Relations	3/1/92	6/30/94
TASK 3 - Field Investigation	5/1/92	2/18/93
Groundwater		
Well Installation		
Sampling		
Surface Water		
Sediment		
Assoc. With Surface Water		
Near Shore		
Soil		
Air		
TASK 4 - Sample Analysis & Data Validation	5/1/92	6/1/93
TASK 5 - Data Evaluation	1/1/93	8/31/93
TASK 6 - Baseline Risk Assessment	1/1/93	12/13/93
TASK 7 - Treatability Studies (if needed)	12/14/93	3/14/94
TASK 8 - Phase I Remedial Investigation Report	1/1/93	12/13/93
EPA Approval of Task 8	12/14/93	1/14/94
TASK 9 - Development & Screening of Remedial Alternatives (if needed)	1/15/94	2/28/94
TASK 10 - Detailed Analysis of Remedial Alternatives (if needed)	3/1/94	4/15/94

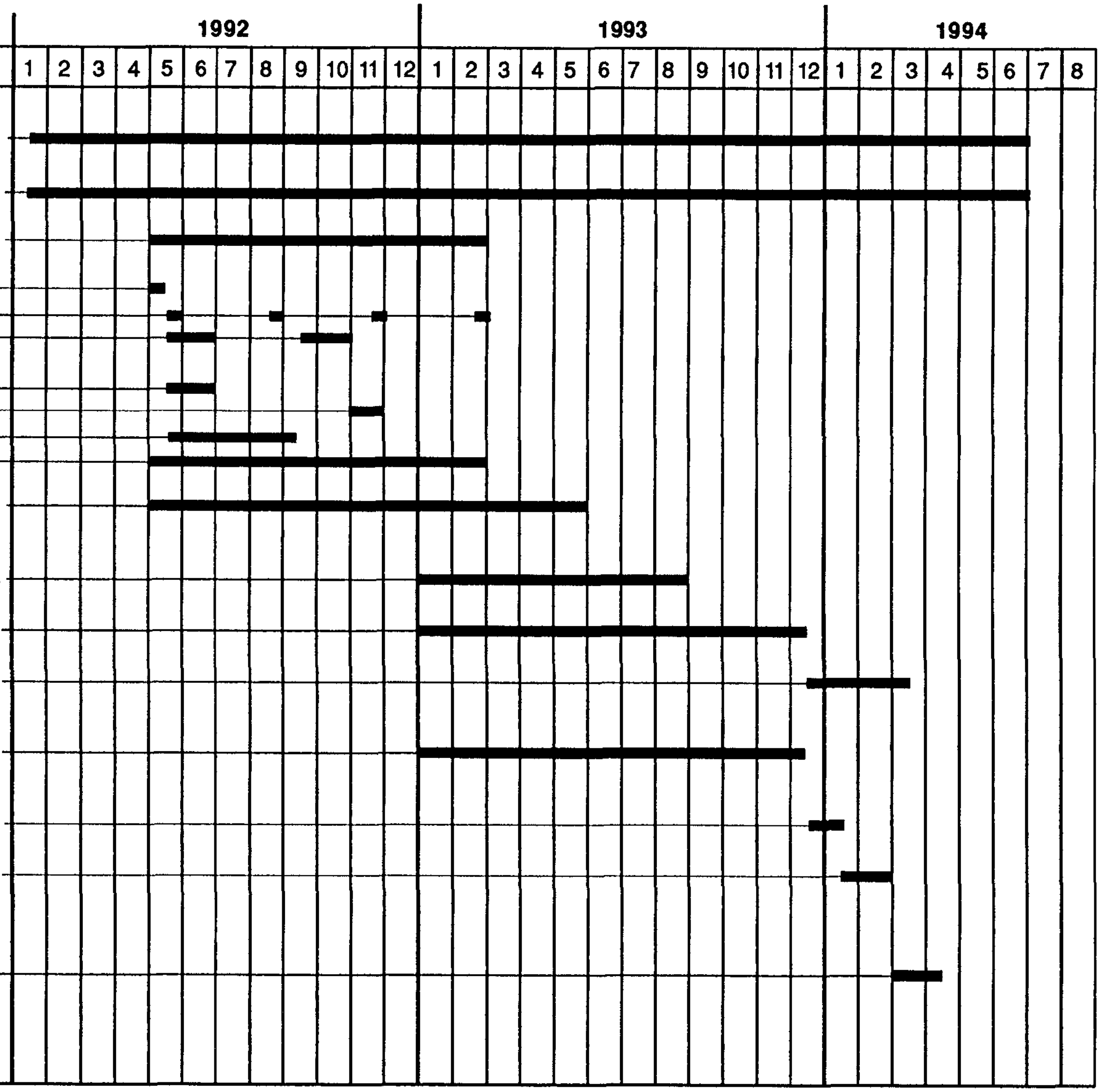


Figure 9-1
Operable Unit 3
Phase I RFI/RI
Conceptual Schedule

QUALITY ASSURANCE ADDENDUM

(QAA 3.1)

to the

ROCKY FLATS PLANT SITE-WIDE QA PROJECT PLAN

FOR CERCLA RI/FS AND RCRA RFI/CMS ACTIVITIES

for

OPERABLE UNIT NO. 3, LAND SURFACE, GREAT WESTERN RESERVOIR, STANDLEY LAKE, AND MOWER RESERVOIR

PHASE I

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

Revision 0

TITLE:
Quality Assurance Addendum for Phase I RFI/RI
Work Plan for Operable Unit 3

Approved by:

________________ ___/___/___
Manager, Remediation Programs

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INTRODUCTION AND SCOPE

This Quality Assurance Addendum (QAA) supplements the "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA RI/FS and RCRA RFI/CMS Activities" (QAPjP) for field investigation activities described in the Phase I RFI/RI Work Plan for Land Surface, Great Western Reservoir, Standley Lake and Mower Reservoir (designated as Operable Unit [OU] No. 3) dated May 1991 (OU-3 Work Plan).

OU-3 is comprised of four Individual Hazardous Substance Sites (IHSSs). The four IHSSs that make up OU-3, as designated in the Interagency Agreement (IAG), are: IHSS 199, contamination of the Land Surface; IHSS 200, Great Western Reservoir; IHSS 201, Standley Lake; and IHSS 202, Mower Reservoir. OU-3 is unique among RFP OUs in that it is located entirely outside the boundaries of the RFP. The locations of each of these IHSSs are shown in Figure 2-1 of the OU-3 Work Plan.

IHSS 199, Contamination of the Land Surface, specifically targets off-site soil contamination as a result of releases from RFP. As presently defined, this IHSS includes all soils outside the RFP boundary that have been contaminated by releases from the RFP. The extent of offsite soil contamination as a result of RFP releases has not been conclusively defined. Therefore, the boundaries of IHSS 199 cannot be delineated. However, based on the results of past studies, IHSS 199 is most likely limited to areas downwind of the RFP, primarily to the northeast, east, and southeast. The primary contaminants of concern are plutonium and americium. A soil sampling program has been developed as part of the OU-3 Field Sampling Plan (FSP) in order to characterize the vertical and lateral extent of soil contamination.

IHSS 200 includes Great Western Reservoir, offsite portions of Walnut Creek, and downstream surface water features that may be impacted as a result of outflow from the reservoir. IHSS 201 includes Standley Lake, offsite portions of Woman Creek that flow into Standley Lake, and downstream surface water features. IHSS 202 includes Mower Reservoir, offsite portions of the irrigation ditch that feeds the reservoir from Woman Creek, and downstream surface water features possibly impacted by outflow from the reservoir. Field sampling associated with these three IHSSs includes collecting samples of sediments, surface water, groundwater, and aquatic biota. Discrete air sampling will also be conducted in low lying areas of Great Western Reservoir and Standley Lake where reservoir sediments are exposed.

1.0 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Management Department (EMD) divisions involved in environmental restoration (ER) activities is shown in Section No. 1.0 of the QAPjP. Specific responsibilities are also described in detail in Section No. 1.0 of the QAPjP.

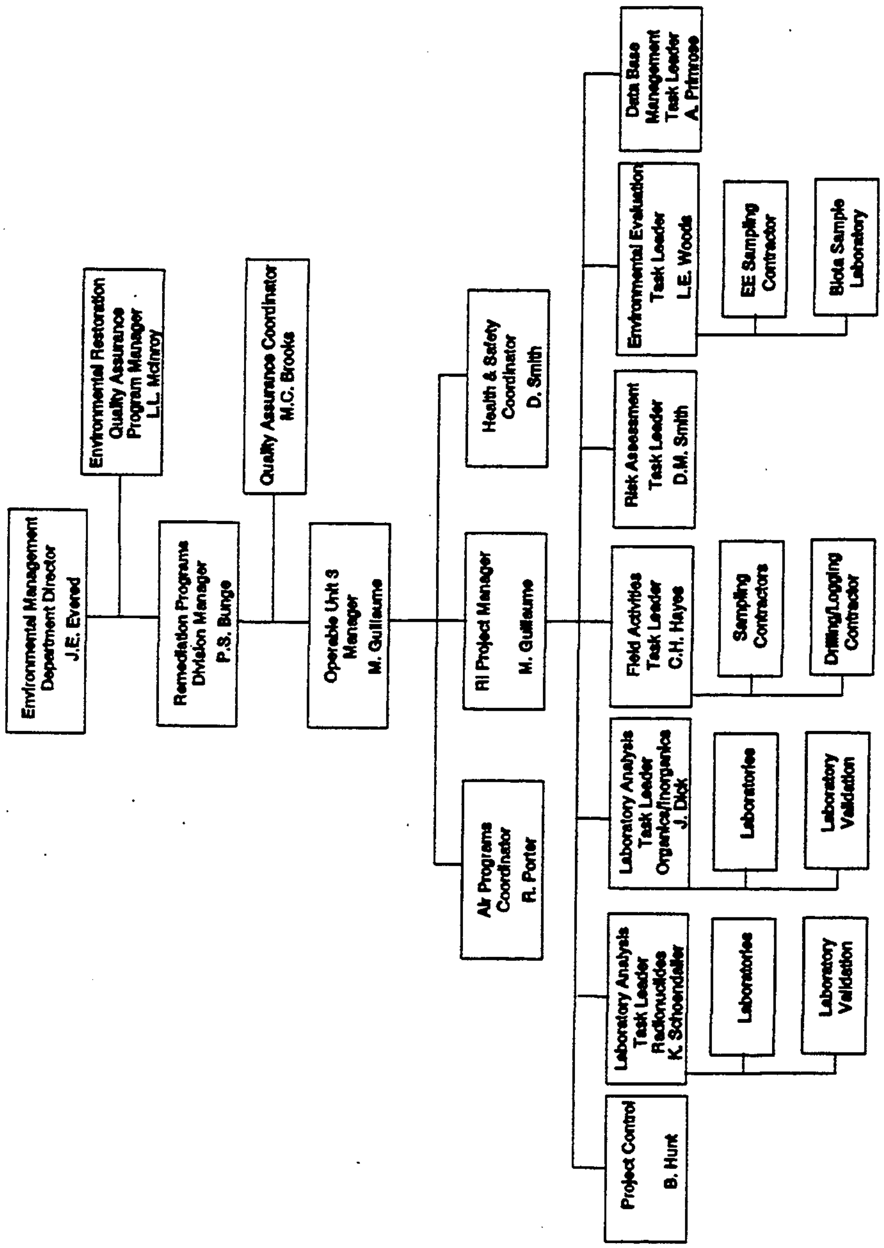
Contractors will be tasked by EG&G Rocky Flats to implement the OU-3 Work Plan. The specific EM Department personnel who will interface with the Contractors and who will be authorized to provide technical direction are shown in Figure 1.

2.0 QUALITY ASSURANCE PROGRAM

The QAPjP was written to specifically address QA controls for related activities. The content of the QAPjP was driven by DOE RFP SOP 5700.6B, which requires that a QA program be implemented for all Rocky Flats Plant (RFP) activities based on ASME NQA-1, "Quality Assurance Requirements for Nuclear Facilities," as well as the IAG, which specifies that a QAPjP for IAG-related activities be developed in accordance with EPA QAMS-005/80, "Interim Guidelines and Specifications for Preparing QAPjPs." The 18-element format of NQA-1 was selected as the basis for both the plan and subsequent QAAs with the applicable elements of EPA QAMS-005/80 incorporated where appropriate.

The QA controls and requirements addressed in the QAPjP are applicable to OU-3 Work Plan activities, unless otherwise specified in this QAA. As a supplement to the QAPjP, this QAA addresses additional and site-specific QA controls and requirements that are applicable to OU-3 Phase I activities.

FIGURE 1. PROJECT MANAGEMENT FOR OPERABLE UNIT 3 PHASE I



2.1 Training

All personnel (including contractor personnel) shall complete the orientation and personnel training specified in Section No. 2.0 of the QAPjP. Additional training is required for all personnel performing activities in accordance with the EMD Operating Procedures (OPS) specified in this QAA. The EMD OPS are also referred to herein and in the QAPjP as Standard Operating Procedures. Those personnel shall receive training in this QAA and the applicable SOPs prior to performing the work.

2.2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of these activities (whichever is more frequent) by the QAPM or designee. The QA report will include a summary of field operation surveillances and audits, laboratory surveillances and audits, and a report of data verification/validation results.

3.0 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

3.1 Design Control

The OU-3 Work Plan is the design control plan for the OU-3 RFI/RI Phase I investigations. The OU-3 Work Plan specifies the objectives of the investigations, discusses the development of data quality objectives applicable to those investigations, describes the design of the field sampling program, provides the rationale for the sampling and analytical programs, and discusses and/or references the proposed sampling and analysis methodologies. The OU-3 Work Plan will be reviewed and approved by the EG&G Rocky Flats Remediation Programs Manager, DOE Rocky Flats Office, the EPA Regional Administrator, and the Director of the Colorado Department of Health (CDH) prior to implementing the work described in the work plan. Once the OU-3 Work Plan has been reviewed and approved, any changes to or revisions of the work plan will also be reviewed and approved by those organizations that reviewed and approved the original work plan.

3.2 Data Quality Objectives

Data quality objectives (DQOs) quantitatively and qualitatively describe the uncertainty that decision makers are willing to accept in results derived from environmental data. This uncertainty is used to specify the quality of the data required to meet the objectives of the investigations. The process of developing DQOs for remedial investigations is summarized in Appendix A of the QAPjP. The development of DQOs for OU-3 investigations follows that process and is presented in Section 5 of the OU-3 Work Plan.

Parameters that are used as indicators of data quality are precision, accuracy, representativeness, comparability, and completeness (referred to as PARCC parameters). The definitions and methods of calculating these parameters are presented in Appendix A of the QAPjP The objectives of the investigations proposed in the OU-3 Work Plan are summarized below and the objectives for the PARCC parameters for OU-3 analytical data are also established.

3.2.1 Objectives

The Field Sampling Plan (FSP) of the OU-3 Work Plan (Section 6) is designed to obtain data necessary to characterize the physical features and ecological characteristics of the sites that make up OU-3, characterize the nature and extent of plutonium and americium at the IHSSs, assess the presence or absence of other potential contaminants in soil, sediments and groundwater, and to collect data to support the Baseline Risk Assessment and Environmental Evaluation. Table 5-1 of the OU-3 Work Plan establishes the types of data that are needed to meet these data uses, summarizes the types of field and analytical activities that will be implemented to obtain the data, and selects the analytical levels that are appropriate for the intended use of the data.

The analytical level that is selected determines the quality of data that will be obtained from sampling and analysis activities. The EPA guidance document for developing DQOs for remedial response activities has established analytical levels I through V; with increasingly rigorous QA/QC applicable at each successively higher level, which in turn produces data of a higher known quality. These analytical levels are defined and discussed in Appendix A of the QAPjP. All five analytical levels are appropriate for the OU-3 remedial investigations.

Analytical levels I and II are applicable to field screening and analysis where qualitative and quantitative data are obtained at the time of sampling from field measurements and sample analysis using portable analytical instruments. The data produced from these field instruments are generally more variable than data obtained from laboratory analytical methods. Since the data from analytical levels I and II are generally more variable, establishing PARCC parameter objectives is usually not applicable; however, objectives for accuracy of field analytical instruments have been established for OU-3 investigations. The objectives for PARCC parameters for OU-3 water and soil/sediment data are discussed in the following sections. PARCC parameter objectives have not yet been established for ecological data.

3.2.2 Precision and Accuracy

The objectives of precision and accuracy are dependent on the analyte of interest, the sample matrix, the analytical method, and the quality control that are applicable to that method. The groundwater, surface water, sediment, and soil samples collected during OU-3 investigations will be analyzed according to methods specified in the Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Parts A and B, which includes EPA CLP protocols and standard EPA methods when CLP protocols are unavailable. The analytes of interest for OU-3 investigations are listed in Table 6-4 of the OU-3 Work Plan. The objectives of precision and accuracy for the analytes listed in the OU-3 Work Plan have been established in Appendix B of the QAPjP. They are also presented in Appendix A of this QAA for convenience.

3.2.3 Completeness

The target objective for completeness for OU-3 analytical data is 90 percent.

3.2.4 Comparability

Comparability is a qualitative parameter that is ensured by implementation of the sampling and analysis plan following standardized field sampling procedures and analytical protocols, and by reporting data in uniform units as specified in the procedures applicable to the OU-3 investigations.

3.2.5 Representativeness

Representativeness is also a qualitative parameter that is ensured through the careful development and review of the sampling and analysis strategy outlined in the OU-3 Work Plan and procedures for sample collection and analysis and field data collection.

3.2.6 DQOs for Environmental Evaluation Investigations

DQOs for the environmental evaluation (EE) investigations described in the FSP and the Environmental Evaluation Work Plan (Section 8) of the OU-3 Work Plan have not yet been determined. The development of DQOs for EE investigation data will follow a review of existing information and completion of initial field surveys which will qualitatively characterize the ecosystems occupied by the OU-3 IHSSs. The review of existing information and completion of initial field surveys will allow investigators to obtain information regarding the presence of site-specific receptor species and potential exposure pathways that are necessary to develop the DQOs. The development of DQOs for the EE will follow the steps recommended by EPA in EPA/600/3-89/013, Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Document, and EPA/540/G-90/008, Guidance for Data Usability in Risk Assessment.

3.3 Field Sampling Program and Sampling Procedures

The field investigation program presented in the FSP (Section 6) of the OU-3 Work Plan includes the following field sampling activities:

- soil profile and surface soil sampling;
- sediment sample collection from ditches and drainage channels upstream and downstream of reservoirs and from the reservoirs;
- surface water sampling from surface water drainages and reservoirs;
- a limited groundwater sampling program that includes continued sampling of 14 existing buffer zone wells, and drilling, logging, installation, and sampling of new alluvium and bedrock monitoring wells;
- discrete air sampling using HiVol samplers to collect particulates from exposed reservoir sediments;

- aquatic biota sampling that includes sampling periphyton, benthic macroinvertebrates, and fish; and

- terrestrial biota sampling that includes collecting vegetation samples from grassland and wetland communities, and small mammal sampling.

These field investigations, including sampling locations, numbers of samples to be collected, and applicable sampling SOPs are discussed in the FSP. The SOPs (also referred to as EMD OPS) that are applicable to the various aspects of the field investigation program are listed here in Table 1.

3.4 Analytical Procedures

The analytical program for OU-3 activities is also discussed in Section 6 of the OU-3 Work Plan. The analytical methods for groundwater, surface water, and soils/sediments for the analytes listed in Table 6-4 of the OU-3 Work Plan that shall be adhered to are those that are specified in Parts A and B of the GRRASP. Those analytical methods are referenced in Section No. 3.0 of the QAPjP. The specific analytical method for each analyte is also referenced here in Appendix A.

The HiVol air filter samples will be brought into the laboratory, dried, and weighed. The weight of the filters will then be compared to previously recorded tare weights of the filters to determine particulate loading. The sample filters will then be split into two equal quantities, with one half used for plutonium measurement and the other for americium measurement. Alpha spectroscopy will be used to analyze the air filter samples for isotopic plutonium (238, 239, and 240), isotopic americium (241), and uranium 233 and 234.

Biotic samples that are collected for potential contaminant analysis will be analyzed for plutonium, americium, chromium, beryllium, lead, cadmium, and nickel. The methods of analysis for metals will include both the inductively coupled argon plasma emission spectroscopy and the graphite furnace atomic absorption spectroscopy methods. The method of analysis for plutonium and americium has not yet been specified.

TABLE 2.1.
EMD Operating Procedures and Field Activities for Which They are Applicable

Former SOP Reference Number	EMD OPS Reference Number	Standard Operating Procedures	Well Drilling, Completion, Development	Ground-Water Sampling	Surface-Water & Reservoir Sampling	Sediment Sampling	Soil Sampling	Biota Sampling	Discrete Air Sampling
1.1	F0.01	Wind Blown Contaminant Dispersion Control	●						
1.2	F0.02	Field Document Control		●	●	●	●	●	
1.3	F0.03	General Equipment Decontamination	●	●	●	●	●	●	
1.4	F0.04	Heavy Equipment Decontamination	●	●	●	●	●	●	
1.5	F0.05	Handling of Purge and Development Water	●	●					
1.6	F0.06	Handling of Personal Protective Equipment	●	●	●	●	●	●	
1.7	F0.07	Handling of Decontamination Water & Wash Water	●	●	●	●	●	●	
1.8	F0.08	Handling of Drilling Fluids & Cuttings	●			●			
1.9	F0.09	Handling of Residual Samples					●	●	
1.10	F0.10	Receiving, Labeling, and Handling Waste Containers	●	●				●	
1.11	F0.11	Field Communications	●	●	●	●	●	●	
1.12	F0.12	Decontamination Facility Operations	●	●	●	●	●	●	
1.13	F0.13	Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples		●	●	●	●	●	
1.14	F0.14	Field Data Management	●	●	●	●	●	●	
1.15	F0.15	Use of PIDs and FIDs	X	X	X	X	X	X	
1.16	F0.16	Field Radiological Measurements							
		a) Walk-Over Surveys	X	X	X	X	X	X	
		b) Sample and Waste Screening	X	X	X	X	X	X	
2.1	GW.01	Water Level Measurements in Wells and Piezometers	●	●					
2.2	GW.02	Well Development							
		a) New Wells	●						
2.6	GW.06	Groundwater Sampling							
		a) Bailer		●					
3.1	GT.01	Logging Alluvial and Bedrock Material	●						
3.2	GT.02	Drilling and Sampling Using Hollow-Stem Auger Techniques	●						

X - As required by H&S plan.

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TABLE 2-1. (Continued) EMD Operating Procedures and Field Activities for Which They are Applicable

Former SOP Reference Number	EMD OPS Reference Number	Standard Operating Procedures	Well Drilling, Completion, Development	Ground-Water Sampling	Surface-Water & Reservoir Sampling	Sediment Sampling	Soil Sampling	Biota Samples	Discrete Air Sampling
3.3	GT.03	Isolating Bedrock from the Alluvium with Grouted Surface Casing	●						
3.6	GT.04	Monitoring Well and Piezometer Installation	●						
3.7	GT.07	Logging and Sampling of Test Pits and Trenches					●		
3.8	GT.08	Surface Soil Sampling					●		
3.11	GT.11	Plugging and Abandonment of Wells	●						
New	GT.17	Land Surveying	●	●	●				
4.1	SW.01	Surface Water Data Collection Activities			●				
4.2	SW.02	Field Measurement of Surface Water Parameters			●				
4.3	SW.03	Surface Water Sampling			●				
4.6	SW.06	Sediment Sampling				●			
4.8	SW.08	Pond Sampling			●				
5.1	EE.01	Sampling of Periphyton						●	
5.2	EE.02	Sampling of Benthic Macroinvertebrates						●	
5.4	EE.04	Sampling of Fishes						●	
5.6	EE.06	Sampling of Small Mammals						●	
5.10	EE.10	Sampling of Terrestrial Vegetation						●	
6.12	MT.15	Preventive Maintenance Procedure for RFP TSP HIVOL Air Sampler							●
New	MT.17	Placement, Design, Installation, and Operation of Particulate and Air Toxics Monitoring Stations							●
New	MT.19	Site-Specific Particulate and Air Toxic Monitoring at Active Investigation Site							●

3.5 Equipment Decontamination

Non-dedicated sampling equipment shall be decontaminated between sampling locations in accordance with SOP 1.3, General Equipment Decontamination. Other equipment (e.g., heavy equipment) potentially contaminated during drilling, boring, sample collection, etc. shall also be decontaminated as specified in SOP 1.4, Heavy Equipment Decontamination. Decontamination water will be handled according to SOP 1.7, Handling of Decontamination Water and Wash Water.

3.6 Quality Control Checks

To assure the quality of the field sampling techniques, collection and/or preparation of field quality control (QC) samples are incorporated into the sampling scheme. These QC samples are defined and the procedure for collection/preparation described in Section No. 3.0 of the QAPjP. Field QC samples and collection frequencies for the field investigations are shown in Table 2. A specific sampling schedule will be prepared by the sampling subcontractor(s) for approval by the Laboratory Analysis Task Leaders (Figure 1) prior to sampling.

In addition, a QC sample, which will consist of an extra volume of a designated field sample (for soil/sediment and water samples), shall be collected at a 5 percent frequency for each specific sample matrix. These QC samples shall be collected and submitted to the laboratory to allow for the analysis of laboratory-prepared QC samples to provide the laboratory with a check on its internal operations. The volume required for the QC sample shall be double that of a normal sample.

3.6.1 <u>Objectives for Field QC Samples</u>

Equipment rinsate blanks are considered acceptable (with no need for data qualification) if the concentration of analytes of interest is less than three times the required detection limit for each analyte as specified in Appendix A. Field duplicate samples should agree within 30 percent relative percent difference for aqueous samples and 40 percent for homogenous, non-aqueous soil/ sediment samples.

TABLE 2
FIELD QC SAMPLE COLLECTION FREQUENCY
(Example)

Activity	Frequency
Field Duplicates	1 in 20[1]
Field Blanks[2]	1 sample per shipping container (or a minimum of 1 per 20 samples)
Trip Blanks[3]	1 in 20
Equipment Rinsate Blanks	1 in 20[4] (or 1 per day of sampling, whichever is more frequent)
Drilling and Decontamination Fluids	Sample source and analyze for all analytes of interest prior to use.
Triplicate Samples (benthic samples)	For each sampling site.

1. Or per sampling event, whichever is more frequent. (A co-located field duplicate will also be collected for each of the discrete air sampling locations for each sampling event.)
2. For groundwater samples to be analyzed for inorganics.
3. For water samples to be analyzed for volatile organics only.
4. One equipment rinsate blank in twenty samples for each specific sample matrix being collected when non-dedicated equipment is being used.

Trip blanks and field blanks (for organics and inorganics, respectively) indicate possible field contamination when analytes are detected above the minimum detection limits presented in Appendix A. The Laboratory Analysis Task Leader (Figure 1) is responsible for verifying these criteria, for checking to see if they are met, and for qualifying data.

3.6.2 Laboratory QC

Laboratory QC procedures are used to provide measures of internal consistency of analytical and storage procedures. The laboratory contractor will submit written SOPs to the Laboratory Analysis Task Leader for approval. These internal laboratory SOPs shall address the issues specified in Parts A and B of the GRRASP and in Section No. 3.0 of the QAPjP. The laboratory QC procedures that are applicable to the analytical methods cited here in Appendix A shall be consistent with or equivalent to EPA-CLP QC procedures. Laboratory QC techniques for ensuring consistency and validity of analytical results (including detecting potential laboratory contamination of samples) include using reagent blanks, field blanks, internal standard reference materials, laboratory replicates, and field duplicates. The laboratory contractor will follow the standard evaluation guidelines and QC procedures, including frequency of QC checks, that are applicable to the particular type of analytical method being used as specified in the GRRASP and Section No. 3.0 of the QAPjP. All results will be forwarded to the Laboratory Analysis Task Leader and validation contractor (Figure 1) for review and verification.

3.7 Data Reduction, Validation, and Reporting

3.7.1 Analytical Reporting Turnaround Times

Analytical reporting turnaround times are as specified in Table 3-1 of the QAPjP.

3.7.2 Data Verification and Validation

Validation activities consist of reviewing and verifying field and laboratory data and evaluating the verified data for data quality (i.e., comparison of reduced data to DQOs, where appropriate). The field and laboratory data validation activities and guidelines are described and referenced in Section

No. 3.0 of the QAPjP. The process for validating the quality of the data is illustrated graphically in Figure 3-1 of the QAPjP, and is also included as part of the sample collection, chain-of-custody, and analysis process illustrated in Figure 8-1 of the QAPjP. The criteria for determining the validity of data are described in Section No. 3.0 of the QAPjP.

3.7.3 Data Reduction

All field data shall be recorded on field sampling data sheets and/or log books as specified in the appropriate field sampling SOP. Field data shall be controlled according to SOP 1.2, Field Document Control. The reduction of field and laboratory data is described in Section No. 3.0 of the QAPjP. All field and laboratory raw data sets shall be verified (as described above) and shall then be input into the EG&G RFEDS environmental database using a remote data entry module (see SOP 1.14, Database Management).

3.7.4 Data Reporting

Depending on the data validation process, data are flagged as either "valid," "acceptable with qualifications," or "rejected." The results of the data validation shall be reported in EMD Data Assessment Summary reports. The usability of data (the criteria of which is also described in Section No. 3.0 of the QAPjP) shall be addressed by the RI Project Manager.

4.0 PROCUREMENT DOCUMENT CONTROL

Contractors will perform the field investigations described in the OU-3 Work Plan. The Contractors will be required to implement all requirements contained in the Work Plan, the QAPjP, this QAA, and all applicable SOPs referenced in these documents. Analytical services will also be contracted for analysis of field samples. Appropriate requirements from the QAPjP, this QAA, and the GRRASP shall be passed on to any organizations performing these analyses. Contractors may also be utilized to validate analytical data packages. Applicable requirements from this QAA shall be transmitted to the validation Contractor.

The implementing Contractors will be required to provide the materials necessary for performing the work described in the OU-3 Work Plan.

Contractors are required to adhere to the requirements of this QAA and QAPjP and may be required to submit their own QA Program, which meets the applicable requirements of the QAPjP and this QAA.

5.0 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

5.1 Work Plans

The OU-3 Work Plan describes the RFI/RI Phase I investigations to be performed. The plan will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings outlined in the QAPjP.

5.2 Procedures

SOPs approved for use are identified in Table 1, which also indicates their applicability. Any additional quality-affecting procedures proposed for use but not identified here will be developed and approved as required by the QAPjP prior to performing the affected activity.

A document change notice (DCN) shall be prepared and submitted by the RI Project Manager for review and approval when a deviation or change to an approved SOP is required to complete the intended field sampling. (Note: these DCNs will replace the use of Standard Operating Procedure Addenda [SOPAs] that are referenced in the current version of the QAPjP.) The DCNs shall be subject to the same review and approval, including DOE, EPA, and CDH, as the original SOP.

6.0 DOCUMENT CONTROL

The following documents will be controlled in accordance with Section No. 6.0 of the QAPjP:

- RFI/RI Work Plan for Operable Unit No. 3;
- RFP Site-Wide Quality Assurance Project Plan for CERCLA RI/FS and RCRA RFI/CMS Activities (QAPjP);
- Quality Assurance Addendum to the Rocky Flats Site-Wide QAPjP for Operable Unit No. 3;
- EMD Operating Procedures (i.e. SOPs) specified in Table 1 of this QAA and any additional procedures not yet identified that may be required to implement OU-3 activities.

7.0 CONTROL OF PURCHASED ITEMS AND SERVICES

Contractors that provide services to support activities described in the OU-3 Work Plan will be selected and evaluated as outlined in Section No. 7.0 of the QAPjP. This includes preaward evaluation/audit of proposed Contractors as well as periodic audit of the acceptability of Contractor performance during the life of the contract. Such audits shall be performed at least annually or once during the life of the project, whichever is more frequent. Also see Section No. 18.0 of the QAPjP regarding quality verification activities.

8.0 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

8.1 Sample Containers/Preservation

Appropriate volumes, containers, preservation requirements, and holding times for all ER Program soil and water matrix samples are presented in Tables 8-1 through 8-4 of the QAPjP. Those requirements are applicable to OU-3 water and soil/sediment samples. Requirements for environmental evaluation samples are included here in Table 3. Air sample filters will be placed in manila folders or envelopes for transporting from the field to the laboratory for drying and weighing.

TABLE 3

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size*
SAMPLES FOR METALS ANALYSES				
TERRESTRIAL VEGETATION				
- Metals Determined by ICP**	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals Determined by GFAA***	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	5 g
Periphyton and Benthic Macroinvertebrates				
- Metals Determined by ICP	6 mos.	Freeze & ship w/dry ice	Plastic	25 g
- Metals Determined by GFAA	6 mos	Freeze & ship w/dry ice	Plastic	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Plastic	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Plastic	5 g

TABLE 3

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size*
SAMPLES FOR RADIONUCLIDE ANALYSES				
Terrestrial Vegetation				
- Uranium 223, 234, 235, 238 Americium 241 Plutonium 239, 240	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	1 kg
Periphyton and Benthic Macroinvertebrates				
- Uranium 233, 234, 245, 238 Americium 241 Plutonium 239, 240	6 mos	Freeze & ship w/dry ice	Plastic	1 kg

* Sample size may vary with specific laboratory requirements.

**ICP = Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe.

***GFAA = Graphite Furnace Atomic Absorption Spectroscopy. Metals to be determined include As, Cd, Li, Pg, Se, and Sr.

8.2 Sample Identification

Samples shall be labeled and identified in accordance with Section No. 8.0 of the QAPjP and the sampling SOPs listed in Table 1. Samples will have unique identification that traces the sample to the source(s) and indicates the media type (e.g., GW for groundwater samples), the sequential number for the sample, the sampling contractors alpha identification, and the date. Labels will also include the method of sampling and the conditions prevailing at the time of sampling.

8.3 Chain-of-Custody

Sample chain-of-custody will be maintained through the application of SOP 1.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples, and as illustrated in Figure 8-1 of the QAPjP for all environmental samples collected during field investigations.

8.4 Control of Field Data

All field descriptions, measurements, and observations shall be recorded in appropriate Data Collection Forms as required by the appropriate sampling SOP. Field data shall be controlled in accordance with SOP 1.2, Field Document Control.

9.0 CONTROL OF PROCESSES

The overall process of collecting samples, performing analysis, and inputting the data into a database is considered a process that requires control. The process is controlled through a series of written procedures that govern and document the work activities. The process is illustrated diagrammatically in Section No. 8.0 of the QAPjP.

10.0 INSPECTION

Procured materials and construction activities (e.g., groundwater monitoring well installation) shall be inspected (as applicable) in accordance with the requirements specified in Section No. 10.0 of the QAPjP and any installation specifications included in the OU-3 Work Plan and field sampling SOPs.

11.0 TEST CONTROL

The test control requirements addressed in Section No. 11.0 of the QAPjP are not applicable to the proposed OU-3 investigation activities.

12.0 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

12.1 Field Equipment

Specific conductivity, temperature, and pH of groundwater samples shall be measured in the field. Field measurements will be taken and the instruments calibrated as specified in SOP 2.5 (see Table 1). Measurements shall be made using the following equipment (or EG&G-approved alternates):

- Specific Conductivity: HACH Conductivity Meter
- pH: HACH pH Meter (this meter will also be used for temperature measurements)
- Temperature: HACH pH Meter

Each piece of field equipment shall have a file that contains:

- Operating instructions;
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or available in the field;

- Calibration methods, frequency, and description of the calibration solutions; and
- Standardization procedures (traceability to nationally recognized standards).

The above information shall, in general, conform to the manufacturer's recommended operating instructions or shall explain the deviation from said instructions.

12.2 Laboratory Equipment

Laboratory analyses will be performed by contracted laboratories. The equipment used to analyze environmental samples shall be calibrated, maintained, and controlled in accordance with the requirements contained in the specific analytical methods used and the instrument manufacturer's instructions. Laboratories are required to submit calibration procedures to EG&G for review and approval. Initial and continuing calibration data for analytical equipment used will be included in the data packages submitted to EG&G by the laboratories.

13.0 HANDLING, STORAGE, AND SHIPPING

Samples shall be packaged, transported, and stored in accordance with SOP 1.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Maximum sample holding times, sample preservative, sample volumes, and sample containers are specified in Tables 8-1 through 8-4 of the QAPjP.

EG&G will develop and implement an EM Department administrative procedure for receiving, handling, and storing construction materials (e.g., well casing) to ensure only appropriate, accepted materials are used and are handled and stored to prevent contamination or damage prior to use/installation.

14.0 STATUS OF INSPECTION, TEST, AND OPERATIONS

The requirements for the identification of inspection, test, and operating status of items, products, systems, or equipment shall be implemented as specified in Section No. 14.0 of the QAPjP. A log specifying the status of all boreholes and groundwater monitoring wells shall be maintained by the

Field Activities Task Leader, which will include: well/borehole identification number, ground elevation, casing depth of hole, depth to alluvial, static water level (as applicable), depth to top and bottom of screen (as applicable), diameter of hole, diameter of casing, and top/bottom of casing.

The status of monitoring/test equipment will be maintained in a log directly traceable to the particular piece of equipment, and status indicator tags shall be attached to equipment where such a tag will not interfere with equipment operation.

15.0 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section No. 15.0 of the QAPjP. Nonconformances identified by the implementing contractor(s) shall be submitted to the EMD QA Program Manager (QAPM) for processing as outlined in the QAPjP.

16.0 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section No. 16.0 of the QAPjP. Conditions adverse to quality identified by the implementing Contractor shall be documented and submitted to the EMD QAPM for processing as outlined in the QAPjP.

17.0 QUALITY ASSURANCE RECORDS

All field records, including field data records, scientific notebooks, drilling logs, etc., are considered QA records and shall be controlled in accordance with the SOP 1.2, Field Document Control. QA records to be generated during OU-3 Work Plan activities include, but are not limited to:

- Field Logs (e.g., sample collection notebooks/logs for water, sediment, and air)
- Calibration Records
- Sample Collection and Chain-of-Custody Records
- Drilling Logs

- Work Plan/Field Sampling Plan
- QAPjP/QAA
- Audit/Surveillance/Inspection Reports
- Nonconformance Reports
- Corrective Action Documentation
- Data Validation Results
- Laboratory Analytical Data Packages
- Procurement/Contracting Documentation
- Training/Qualification Records
- Inspection Records

All QA records generated during the planning, implementation, and closure of the activities for OU-3 will be submitted to the EMD Custodian for processing according to the EM Department QA records system described in Section No. 17.0 of the QAPjP.

18.0 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified in Section No. 18.0 of the QAPjP. EG&G will conduct audits of the laboratory contractor as specified in Parts A and B of the GRRASP. The EMD QAPM shall develop a surveillance schedule with the surveillance intervals based on the importance and complexity of each sampling/analytical activity. Intervals will also be based on the schedule contained in Section 9.0 of the OU-3 Work Plan.

Specific tasks that will be monitored by the surveillance program are as follows: (the following are presented as examples)

- Borings and well installations (approximately 10 percent of the holes)
- Field Sampling (approximately 5 percent of each type of sample collected)
- Records Management (a surveillance will be conducted once at the initiation of OU-3 activities, and monthly thereafter)
- Data Verification, validation, and reporting

Audits of Contractors providing field investigation, construction, and analytical support services shall be performed at least annually or once during the life of the project, whichever is more frequent.

A Readiness Review shall be conducted by the EMD QAPM prior to the implementation of OU-3 field investigation activities. The readiness review will determine if all activity prerequisites have been met that are required to begin work. The applicable requirements of the QAPjP and this QAA will be addressed.

19.0 SOFTWARE CONTROL

The requirements for software development and control shall be implemented as specified in Section No. 19.0 of the QAPjP. Computer software utilized by Contractors will be furnished by EG&G. Only database and spreadsheet software will be used for the OU-3 Work Plan activities. The procedure applicable to the use of the database that stores environmental data in the field is SOP 1.14, Field Data Management.

APPENDIX A

Analytical Methods, Detection Limits, and Data Quality Objectives

(Note: The following table is presented as an example. Each Appendix A will be modified as necessary for each work plan.)

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
INDICATORS									
Total Suspended Solids	EPA 160.2[d]	X[U]				10 mg/L	NA	20%RPD[f]	80-120% LCS Recovery
Total Dissolved Solids	EPA 160.1[d]	X[F]	X[F]			5 mg/L	NA	20%RPD[f]	80-120% LCS Recovery
pH	EPA 150.1[d]	X[U]	X[F]			0.1 pH units	0.1 pH units	NA	±0.05 pH units
INORGANICS									
Target Analyte List - Metals		X[F]	X[F]	X	X			WATER/SOIL	WATER/SOIL
Aluminum	EPA CLP SOW[a]					200 ug/L[4]	40 mg/Kg[4]	**	***
Antimony	EPA CLP SOW[a]					60	12		
Arsenic (GFAA)	EPA CLP SOW[a]					10	2		
Barium	EPA CLP SOW[a]					200	40		
Beryllium	EPA CLP SOW[a]					5	1.0		
Cadmium	EPA CLP SOW[a]					5	1.0		
Calcium	EPA CLP SOW[a]					5000	2000		
Chromium	EPA CLP SOW[a]					10	2.0		
Cobalt	EPA CLP SOW[a]					50	10		
Copper	EPA CLP SOW[a]					25	5.0		
Cyanide	EPA 335.3 (modified for CLP)[a,d]					5	10		
Iron	EPA CLP SOW[a]					100 ug/L[4]	20 mg/Kg[4]		
Lead (GFAA)	EPA CLP SOW[a]					3	1.0		
Magnesium	EPA CLP SOW[a]					5000	2000		
Manganese	EPA CLP SOW[a]					15	3.0		
Mercury (CVAA)	EPA CLP SOW[a]					0.2	0.2		
Nickel	EPA CLP SOW[a]					40	8.0		
Potassium	EPA CLP SOW[a]					5000	2000		
Selenium (GFAA)	EPA CLP SOW[a]					5	1.0		
Silver	EPA CLP SOW[a]					10	2.0		
Sodium	EPA CLP SOW[a]					5000	2000		
Thallium (GFAA)	EPA CLP SOW[a]					10	2.0		
Vanadium	EPA CLP SOW[a]					50	10		
Zinc	EPA CLP SOW[a]					20	4.0		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
ANIONS								Water/Soil	Water/Soil
Carbonate	EPA 310.1[d]	X[U]	X[U]			10 mg/L	NA	Same as metals	Same as metals
Bicarbonate	EPA 310.1[d]	X[U]	X[U]			10 mg/L	NA		
Chloride	EPA 325.2[d]	X[U]	X[U]			5 mg/L	NA		
Sulfate	EPA 375.4[d]	X[U]	X[U]			5 mg/L	NA		
Nitrate as N	EPA 353.2[d] or 353.3[d]	X[U]	X[U]			1 mg/L	NA		
Target Compound List - Volatiles	EPA CLP SOW[c]	X[U]	X[U]	X	X			WATER/SOIL	WATER/SOIL
Chloromethane	EPA CLP SOW[c]					10 ug/L	10 ug/Kg (low)[3]	**	***
Bromomethane	EPA CLP SOW[c]					10	10		
Vinyl Chloride	EPA CLP SOW[c]					10	10		
Chloroethane	EPA CLP SOW[c]					10	10		
Methylene Chloride	EPA CLP SOW[c]					5	5		
Acetone	EPA CLP SOW[c]					10	10		
Carbon Disulfide	EPA CLP SOW[c]					5	5		
1,1-Dichloroethene	EPA CLP SOW[c]					5	5		
1,1-Dichororethane	EPA CLP SOW[c]					5 ug/L	5 ug/Kg(low)[3]		
total 1,2-Dichloroethene	EPA CLP SOW[c]					5	5		
Chloroform	EPA CLP SOW[c]					5	5		
1,2-Dichloroethane	EPA CLP SOW[c]					1	5		
2-Butanone	EPA CLP SOW[c]					10	10		
1,1,1-Trichoroethane	EPA CLP SOW[c]					5	5		
Carbon Tetrachloride	EPA CLP SOW[c]					5	5		
Vinyl Acetate	EPA CLP SOW[c]					10	10		
Bromodichloromethane	EPA CLP SOW[c]					5	5		
1,2-Dichloropropane	EPA CLP SOW[c]					5	5		
cis-1,3-Dichloropropene	EPA CLP SOW[c]					5	5		
Trichloroethene	EPA CLP SOW[c]					5	5		
Dibromochloromethane	EPA CLP SOW[c]					5	5		
1,1,2-Trichloroethane	EPA CLP SOW[c]					5	5		
Benzene	EPA CLP SOW[c]					5	5		
trans-1,2-Dichloropropene	EPA CLP SOW[c]					5	5		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Bromoform	EPA CLP SOW[c]					5	5		
4-Methyl-2-pentanone	EPA CLP SOW[c]					10	10		
2-Hexanone	EPA CLP SOW[c]					10	10		
Tetrachloroethene	EPA CLP SOW[c]					5	5		

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Volatiles (continued)		X[U]	X[U]	X	X			WATER/SOIL	WATER/SOIL
Toluene	EPA CLP SOW[c]					5	5	**	***
1,1,2,2-Tetrachoroethane	EPA CLP SOW[c]					5	5		
Chlorobenzene	EPA CLP SOW[c]					5	5		
Ethyl Benzene	EPA CLP SOW[c]					5	5		
Styrene	EPA CLP SOW[c]					5	5		
Total Xylenes	EPA CLP SOW[c]					5	5		
Target Compound List - Semi-Volatiles			X[U]	X	X			WATER/SOIL	WATER/SOIL
Phenol	EPA CLP SOW[c]					10 ug/L	330 ug/Kg[3]	**	***
bis(2-Chloroethyl)ether	EPA CLP SOW[c]					10	330		
2-Chlorophenol	EPA CLP SOW[c]					10	330		
1,3-Dichlorobenzene	EPA CLP SOW[c]					10	330		
1,4-Dichlorobenzene	EPA CLP SOW[c]					10	330		
Benzyl Alcohol	EPA CLP SOW[c]					10	330		
1,2-Dichlorobenzene	EPA CLP SOW[c]					10	330		
2-Methylphenol	EPA CLP SOW[c]					10	330		
bis(2-Chloroisopropyl)ether	EPA CLP SOW[c]					10	330		
4-Methylphenol	EPA CLP SOW[c]					10	330		
N-Nitroso-Dipropylamine	EPA CLP SOW[c]					10	330		
Hexachloroethane	EPA CLP SOW[c]					10	330		
Nitrobenzene	EPA CLP SOW[c]					10	330		
Isophorone	EPA CLP SOW[c]					10	330		
2-Nitrophenol	EPA CLP SOW[c]					10	330		
2,4-Dimethylphenol	EPA CLP SOW[c]					10	330		
Benzoic Acid	EPA CLP SOW[c]					50	1600		
bis(2-Choroethoxy)methane	EPA CLP SOW[c]					10	330		
2,4-Dichlorophenol	EPA CLP SOW[c]					10	330		
1,2,4-Trichlorobenzene	EPA CLP SOW[c]					10	330		
Naphthalene	EPA CLP SOW[c]					10	330		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	BOREHOLE	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
4-Chloroanaline	EPA CLP SOW[c]								
Hexachlorobutadiene	EPA CLP SOW[c]					10	330		
4-Chloro-3-methylphenol	EPA CLP SOW[c]					10	330		
2-Methylnaphthalene	EPA CLP SOW[c]					10	330		
Hexachlorocyclopentadiene	EPA CLP SOW[c]					10	330		
2,4,6-Trichlorophenol	EPA CLP SOW[c]					10 ug/L	330 ug/Kg[3]		
2,4,5-Trichlorophenol	EPA CLP SOW[c]					10	330		
2-Chloronaphthalene	EPA CLP SOW[c]					50	1600		
						10	330		
Target Compound List - Semi-Volatiles (continued)			X[U]	X	X			WATER/SOIL	WATER/SOIL
2-Nitroanaline	EPA CLP SOW[c]								
Dimethylphthalate	EPA CLP SOW[c]					50	1600	**	***
Acenaphthylene	EPA CLP SOW[c]					10	330		
2,6-Dinitrotoluene	EPA CLP SOW[c]					10	330		
3-Nitroaniline	EPA CLP SOW[c]					10	330		
Acenaphthene	EPA CLP SOW[c]					50	1600		
2,4-Dinitrophenol	EPA CLP SOW[c]					10	330		
4-Nitrophenol	EPA CLP SOW[c]					50	1600		
Dibenzofuran	EPA CLP SOW[c]					50	1600		
2,4-Dinitrotoluene	EPA CLP SOW[c]					10	330		
Diethylphthalate	EPA CLP SOW[c]					10	330		
4-Chlorophenol Phenyl ether	EPA CLP SOW[c]					10	330		
Fluorene	EPA CLP SOW[c]					10	330		
4-Nitroanaline	EPA CLP SOW[c]					10	330		
4,6-Dinitro-2-methylphenol	EPA CLP SOW[c]					50	1600		
N-nitrosodiphenylamine	EPA CLP SOW[c]					50	1600		
4-Bromophenyl Phenyl ether	EPA CLP SOW[c]					10	330		
Hexachlorobenzene	EPA CLP SOW[c]					10	330		
Pentachlorophenol	EPA CLP SOW[c]					10	330		
Phenanthrene	EPA CLP SOW[c]					50	1600		
Anthracene	EPA CLP SOW[c]					10	330		
Di-n-butylphthalate	EPA CLP SOW[c]					10 ug/L	330 ug/Kg[3]		
Fluoranthene	EPA CLP SOW[c]					10	330		
Pyrene	EPA CLP SOW[c]					10	330		
Butyl Benzylphthalate	EPA CLP SOW[c]					10	330		
3,3'-Dichlorobenzidine	EPA CLP SOW[c]					10	330		
Benzo(a)anthracene	EPA CLP SOW[c]					20	660		
						10	330		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Chrysene	EPA CLP SOW[c]	10	330
bis(2-ethylhexyl)phthalate	EPA CLP SOW[c]	10	330
Di-n-octyl Phthalate	EPA CLP SOW[c]	10	330
Benzo(b)fluoranthene	EPA CLP SOW[c]	10	330
Benzo(k)fluoranthene	EPA CLP SOW[c]	10	330
Benzo(a)pyrene	EPA CLP SOW[c]	10	330
Indeno(1,2,3-cd)pyrene	EPA CLP SOW[c]	10	330
Dibenz(a,h)anthracene	EPA CLP SOW[c]	10	330
Benzo(g,h,i)perylene	EPA CLP SOW[c]	10	330

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	BOREHOLE	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Pesticides/PCBs			X^{U}	X	X			WATER/SOIL (%RPD)	WATER/SOIL (% Recovery)
alpha-BHC	EPA CLP SOW^{c}					0.05 ug/L	8.0 ug/Kg^{3}	**	***
beta-BHC	EPA CLP SOW^{c}					0.05	8.0		
delta-BHC	EPA CLP SOW^{c}					0.05	8.0		
gamma-BHC (Lindane)	EPA CLP SOW^{c}					0.05	8.0		
Heptachlor	EPA CLP SOW^{c}					0.05	8.0		
Aldrin	EPA CLP SOW^{c}					0.05 ug/L	8.0 ug/Kg^{3}		
Heptachlor Epoxide	EPA CLP SOW^{c}					0.05	8.0		
Endosulfan I	EPA CLP SOW^{c}					0.05	8.0		
Dieldrin	EPA CLP SOW^{c}					0.10	16.0		
4,4'-DDE	EPA CLP SOW^{c}					0.10	16.0		
Endrin	EPA CLP SOW^{c}					0.10	16.0		
Endosulfan II	EPA CLP SOW^{c}					0.10	16.0		
4,4'-DDD	EPA CLP SOW^{c}					0.10	16.0		
Endosulfan Sulfate	EPA CLP SOW^{c}					0.10	16.0		
4,4'-DDT	EPA CLP SOW^{c}					0.10	16.0		
Methoxychlor	EPA CLP SOW^{c}					0.5	80.0		
Endrin Ketone	EPA CLP SOW^{c}					0.10	16.0		
alpha-Chlordane	EPA CLP SOW^{c}					0.5	80.0		
gamma-Chlordane	EPA CLP SOW^{c}					0.5	80.0		
Toxaphene	EPA CLP SOW^{c}					1.0	160.0		
AROCLOR-1016	EPA CLP SOW^{c}					0.5	80.0		
AROCLOR-1221	EPA CLP SOW^{c}					0.5	80.0		
AROCLOR-1232	EPA CLP SOW^{c}					0.5	80.0		
AROCLOR-1242	EPA CLP SOW^{c}					0.5	80.0		
AROCLOR-1248	EPA CLP SOW^{c}					0.5	80.0		
AROCLOR-1254	EPA CLP SOW^{c}					1.0	160.0		
AROCLOR-1260	EPA CLP SOW^{c}					1.0	160.0		
RADIONUCLIDES								(Replicate Analyses)	(Laboratory Control Sample)
Gross Alpha	s,f,g,h,i,k,l,m,n	X^{F,U}	X^{F}	X	X	2 pCi/L	4 pCi/g	**	***
Gross Beta	s,f,g,h,i,k,l,m,n	X^{F,U}	X^{F}	X	X	4 pCi/L	10 pCi/g		
Uranium 233+234	f,h,i,m,n,s,l	X^{F,U}	X^{F}	X	X	0.6 pCi/L	0.3 pCi/g		
Uranium 235,238	f,h,i,m,n,s,l	X^{F,U}	X^{F}	X	X	0.6 pCi/L	0.3 pCi/g		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Americium 241	p,q,s,l,i	$X^{F,U}$	X^{F}	X	X	0.01 pCi/L	0.02 pCi/g		
Plutonium 239+240	o,p,s,l,i	$X^{F,U}$	X^{F}	X	X	0.01 pCi/L	0.03 pCi/g		
Tritium	f,g,h,m,s,i,l	X^{U}	X^{U}	X	X	400 pCi/L	400 pCi/L		
Strontium 89,90	f,h,i,m,s,l			X	X	NA	1 pCi/g		
Analyte	**Method**	**SW**	**GW**	**BOREHOLE**	**SED**	**Required Detection Limits Water**	**Soil/Sed.**	**Precision Objective**	**Accuracy Objective**

RADIONUCLIDES - cont.

Strontium 90 only	f,h,i,m,s,l	$X^{F,U}$	X^{F}			1 pCi/L	NA
Cesium 137	m,h,l,i	$X^{F,U}$	X^{F}	X	X	1 pCi/L	0.1 pCi/g

FIELD PARAMETERS

Analyte	Method	SW	GW	BOREHOLE	SED	Readability Objective	Accuracy
pH	1	X	X			± 0.1 pH unit	± 0.2 pH units
Specific Conductance	1	X	X			2.5 umho/cm[7] 25 umho/cm[8] 250 umho/cm[9]	± 2.5% max. error at 500, 5000, 50000 umhos/cm plus probe; ± 3.0% max error at 250, 2500, and 25000 plus probe accuracy of ± 2.0%.
Temperature	1	X	X			± 0.1°C	± 1.0°C
Dissolved Oxygen	1	X				± 0.1 mg/L	± 10%
Barometric Pressure	1						

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

7. On 500 umho/cm range.
8. On 5000 umho/cm range.
9. On 50000 umho/cm range.

a. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version).

b. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version). The specific method to be utilized is at the laboratory's discretion provided it meets the specified detection limit.

c. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 2/88 (or latest version).

d. Methods are from "Methods for Chemical Analysis of Water and Wastes," U.S. Environmental Protection Agency, 1983, unless otherwise indicated.

e. Methods are from "Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods," (SW-846, 3rd Ed.), U.S. Environmental Protection Agency.

f. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EMSL-LY-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.

g. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.

h. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.

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j. U.S. EPA, 1982. "Methods for Organic Analysis of Municipal and Industrial Waste Water," US EPA-600/4-82-057.

k. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.

l. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, August 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

m. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.

n. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.

o. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium, and Americium," by E.H. Essington and B.J. Drennon, Los Alamos National Laboratory, a private communication.

p. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.

q. "Radioactivity in Drinking Water," EPA 570/9-81-002.

r. If the sample or duplicate result is <5 x IDL, then the control limit is ± IDL.

s. U.S. EPA, 1987. "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual," EPA-520/5-84-006.

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

* For samples collected from IHSSs 102 and 105 only [BH01,BH02,BH03,BH04,BH05,BH06,BH07,BH08 (MW33),BH09,BH15,BH16,BH17,BH18,MW01,MW02,MW03,MW33 (BH08)].
** Precision objective = control limits specified in referenced method and/or Data Validation Guidelines.
*** Accuracy objective = control limits specified in referenced method (in GRRASP for radionuclides).
F = Filtered
U = Unfiltered

1. Measured in the field in accordance with instrument manufacturer's instructions. The instruments to be used are specified in Section 12.
2. Medium soil/sediment required detection limits for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment required detection limit.
3. Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.
4. Higher detection limits may only be used in the following circumstance: If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the required detection limit. This is illustrated in the example below:

   For lead:

   Method in use - ICP
   Instrument Detection Limit (IDL) - 40
   Sample Concentration - 220
   Required Detection Limit (RDL) - 3

   The value of 220 may be reported even though the instrument detection limit is greater than the RDL.

   Note: The specified detection limits are based on a pure water matrix. The detection limits for samples may be considerably higher depending on the sample matrix.
5. If gross alpha > 5 pCi/L, analyze for Radium 226; if Radium 226 > 3 pCi/L, analyze for Radium 228.
6. The detection limits presented were calculated using the formula in N.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LLD = \frac{4.66\ (BKG/BKG\ DUR)^{1/2}}{(2.22)(Eff)(CR)(SR)(e^{-\lambda t})(Aliq)}$$

$$MDA = \frac{4.66\ (BKG/Sample\ DUR)^{1/2}}{(2.22)(Eff)(CR)(SR)e^{-\lambda t}(Aliq)}$$

Where:

LLD = Lower Limit of Detection in pCi per sample unit.
BKG = Instrument Background in counts per minute (CPM).
Eff = Counting efficiency in cpm/disintegration per minute (dpm).
CR = Fractional radiochemical yield.
SR = Fractional radiochemical yield of a known solution.
λ = The radioactive decay constant for the particular radionuclide.
t = The elapsed time between sample collection and counting.
Aliq = Sample volume.
BKG DUR = Background count duration in minutes.

MDA = Minimum Detectable Activity in pCi per sample unit
BKG = same as for LLD
Eff = same as for LLD
CR = same as for LLD
SR = same as for LLD
λ = same as for LLD
t = same as for LLD
Aliq = same as for LLD
Sample DUR = sample count duration in minutes

11.0 STANDARD OPERATING PROCEDURES AND PROCEDURE CHANGE NOTICES

The following RFP program-wide standard operating procedures (SOPs) will be utilized where appropriate during the specific field investigations for OU 3. A complete list of the SOPs to be used follows.

FIELD OPERATIONS

SOP Number

- 1.1–Windblown Contaminant Dispersion Control
- 1.2–Field Document Control
- 1.3–General Equipment Decontamination
- 1.4–Heavy Equipment Decontamination
- 1.5–Handling of Purge and Development Water
- 1.6–Handling of Personal Protective Equipment
- 1.7–Handling of Decontamination Water and Wash Water
- 1.8–Handling of Drilling Fluids and Cuttings
- 1.9–Handling of Residual Samples
- 1.10–Receiving, Labeling, and Handling of Waste Containers
- 1.11–Field Communications
- 1.12–Decontamination Facility Operations
- 1.13–Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples
- 1.14–Field Data Management
- 1.15–Use of Photoionizing and Flame Ionizing Detectors
- 1.16–Field Radiological Measurements

GROUNDWATER

SOP Number

- 2.1–Water Level Measurements in Wells and Piezometers
- 2.2–Well Development
- 2.5–Measurement for Groundwater Field Parameters
- 2.6–Groundwater Sampling

GEOTECHNICAL

SOP Number

- 3.1–Logging Alluvial and Bedrock Material
- 3.2–Drilling and Sampling Using Hollow-Stem Auger Techniques
- 3.3–Isolating Bedrock from Alluvium with Grouted Surface Casing
- 3.4–Rotary Drilling and Rock Coring
- 3.5–Plugging and Abandonment of Boreholes
- 3.6–Monitoring Well and Piezometer Installation
- 3.8–Surface Soil Sampling
- 3.10–Borehole Clearing
- 3.11–Plugging and Abandonment of Wells

SURFACE WATER

SOP Number

- 4.1–Surface Water Data Collection Activities
- 4.2–Field Measurements of Surface Water Field Parameters
- 4.3–Surface Water Sampling

- 4.6–Sediment Sampling
- 4.8–Pond Sampling

ECOLOGY

SOP Number

- 5.1–Sampling of Periphyton
- 5.2–Sampling of Benthic Macroinvertebrates
- 5.4–Sampling of Fishes
- 5.5–Sampling of Large Mammals
- 5.6–Sampling of Small Mammals
- 5.7–Sampling of Birds
- 5.8–Sampling of Reptiles and Amphibians
- 5.9–Sampling of Terrestrial Arthropods
- 5.10–Sampling of Terrestrial Vegetation
- 5.11–Identification of Habitat Types
- 5.12–Sampling of Soil for Soil Description
- 5.13–Development of Field Sampling Plans

AIR

SOP Number

- 6.1–Effluent Tritium Sample Collection
- 6.2–Tritium Sampler Calibration
- 6.3–Effluent Air Radioparticulate Sample Collection
- 6.4–Effluent Air Radioparticulate
- 6.5–Response to Effluent SAAM ALAR
- 6.6–Effluent Air Pitot Tube Inspection and Replacement

- 6.7–Effluent Air Sample Data Reduction
- 6.12–Preventive Maintenance Procedure for RFP TSP Hivol Sampler

Specific information, including appropriate SOP references concerning sampling activities is provided in Section 6.0 for most of the sampling activities. Project-specific details for this work plan not addressed by the SOPs are included in the following procedure change notices. These procedure change notices will be attached to the SOP for use during field activities.

11.1 PROCEDURE CHANGE NOTICE TO SOP NO. GT.7: LOGGING AND SAMPLING OF TEST PITS

SOP GT.7 describes general equipment and procedures that will be used for excavating, sampling, and logging test pits. This standard operating procedure addendum (SOPA) describes specific sample collection, sample analysis, and logging techniques that will be used during the implementation of the OU 3.

The following procedures are taken from well-established soil science and soil chemistry methodologies. For more information regarding the specific analyses, the user is referred to the appropriate chapters in Methods of Soil Analysis (1982) Page et. al. (ed) Part 2 Second Edition Agronomy 9, Soil Science Society of America, Madison, Wisconsin.

11.1.1 Sampling Equipment and Procedures

11.1.1.1 Materials and Equipment Required for Excavating and Sampling Soil Pits

The following is a list of materials and equipment required for this procedure:

- Spade (long handle)
- Trowel
- Stainless steel scoop

- Stainless steel lab spoon
- Stainless steel template (3 cm x 20 cm)
- Sample labels
- Sample containers
- Wash/rinse tubs
- Nonphosphate detergent
- Distilled water
- Plastic sheeting
- Color book
- Measuring tape (metric)
- Wide-base flag
- Cutting knife
- Long nails (15 cm)
- Appropriate health and safety equipment
- Logbook.

11.1.1.2 Soil Excavation Procedures

In addition to the procedures described in SOP GT.7, the following procedures will be conducted for excavating soil pits:

- The soil pits will be dug in "undisturbed" or, at the least-disturbed sites that are characterized by the natural short grass prairie, pasture, and valley side vegetation.

- All soil pits will be excavated with a backhoe. The dimensions of all pits will be approximately 7 feet long, 5 feet wide, and 4 feet deep.

- The vegetation at the surface of the selected wall will be cropped closely to the surface and discarded.

11.1.1.3 Soil Sampling Procedures

In addition to the sampling procedures described in SOP GT.7, the following procedures will be conducted for sampling soil pits:

- A wide-base flag will be placed on the ground surface of a given pit and the depth below surface for each sample will be measured from the base of the flag.

- The soil sampling for assessing plutonium content with depth consists of 10 samples taken according to the following scheme: four samples from the upper 12 cm at 3 cm intervals; two samples from the next 12 cm at 6 cm intervals; two samples from the next 24 cm at 12 cm intervals; and the final two samples from the next 48 cm at 24 cm intervals (the upper 96 cm of the pit will be sampled).

- Soil samples will be collected by using a stainless steel scoop and template (approximately 3 cm x 20 cm), which will be pressed into the wall of the pit. Three samples from each depth (one from the approximate center of the pit face and one from each side of the center sample, at least 1 foot away) will be consolidated to provide a better representation of the site.

- After a sample has been collected, the soil layers beneath the sampled layer will be scraped to expose a fresh face to prevent possible cross-contamination from falling soil material to the upper layer.

11.1.2 Logging of Test Pits

SOP GT.7 requires geologic logging of test pits in accordance with SOP GT.1, Logging Alluvial and Bedrock Material. However, the OU 3 test pit program requires that the soil profiles in the test pits be described and logged by a certified soil scientist (or equivalent) using Soil Conservation Service (SCS) protocols (Figure 11-1). These protocols will be implemented by a qualified professional

SOIL PROFILE DESCRIPTION FORM

Date: ______________________________ Stop No.: ______________________________

Survey Crew Members: ____

Soil Type: ____

Classification: ____

Location: ______________________________ Elev.: ______________

Aspect: __________ Slope (%): __________ Slope Position: __________

Parent Material: ____

Drainage: __________ Veg. Community: ______________________________

Veg. Species and % Comp.: ____

____

____

Notes: ____

____

____

Horizon	Depth	Boundary	Color D or M	Coarse Fragment	Texture	Structure	Consistency	Reaction	Roots/ Pores

Figure 11-1
Soil Profile Description Form

using Soil Survey Manual, (430-V-55M), Soil Survey Staff, USDA, working draft, U.S. Government Printing Office, Washington, D.C., 1981, for guidance.

11.1.3 Decontamination

Excavation equipment will be decontaminated prior to excavating each trench or pit and at the conclusion of the operation. Sampling and peeling equipment will be decontaminated before collecting each sample. Care will be taken to inspect and monitor all excavation equipment, especially the backhoe, to ensure that no hydraulic and/or fuel leaks add contaminants to the site.

Specific decontamination procedures are described in SOP FO.3–General Equipment Decontamination and SOP FO.4–Heavy Equipment Decontamination.

11.1.4 Documentation

All field information required by this SOPA will be documented on Form GT.7D. Field observations and data will be recorded with black ink on the field data form.

11.2 PROCEDURE CHANGE NOTICE TO SOP NO. 4.6, SEDIMENT SAMPLING

The sediment samples collected from the reservoir will be collected using gravity corer. The gravity corer is a method described in A Compendium of Superfund Field Operations, (EPA, 1987a).

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Corers are capable of collecting samples of most sludges and sediments. The corers collect essentially undisturbed samples that represent the profile of strata which may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the cores, penetration to depths of 75 cm (30 in) can be attained. Care should be exercised when using gravity corers in vessels or lagoons that have liners, since penetration depths could exceed that of substrate and result in damage to the liner material.

The following describes the procedures for using a gravity corer:

- Attach a precleaned corer to the required length of sample line. Solid braided 5 mm (3/16 in) nylon line is sufficient; 20 mm (3/4 in) nylon, however, is easier to grasp during hand hoisting.

- Secure the free end of the line to a fixed support to prevent accidental loss of the corer.

- Measure and mark distance to top of sludge on sampler line to determine depth of sludge or sediment coring.

- Allow corer to free fall through liquid to bottom.

- Determine depth of sludge penetration.

- Retrieve corer with a smooth, continuous lifting motion. Do not bump corer because this may result in some sample loss.

- Remove nosepiece from corer, and slide sample out of corer into a stainless steel or Teflon pan.

- Select sample interval as described in the field sampling plan (Section 6.0).

- Transfer sample into appropriate sample bottle with a stainless steel laboratory spoon, scoop, or spatula.

11.3 PROCEDURE CHANGE NOTICE TO SOP NO. 4.8, POND SAMPLING

The pond sampling SOP is amended to address stratified reservoir sampling. Prior to sampling at each sampling point, profiles of water temperature and dissolved oxygen in the water column will be collected at the sampling location. The Hydrolab Multi-Parameter Measuring Instrument will be used to collect the profiles across the entire water column. The sampling will be performed from a boat.

Temperature and dissolved oxygen at the sampling point in the deepest part of the reservoir will be measured to determine the location of stratified layers at this point. The grab samples will then be collected using a Kemmerer sampler in each stratified zone for all samples. The uppermost stratified zone will be sampled first, followed by the next lower zone, and so on. The zone at the bottom of the pond will be sampled last.

11.4 PROCEDURE CHANGE NOTICE TO SOP 5.4, SAMPLING OF FISH

Fish samples from the OU 3 reservoirs will be collected using a boat-mounted boom electroshocker and gill nets. These fishing methods are discussed in detail by Vibert (1967) and Nielsen and Johnson (1983).

The boat-mounted electroshocker is powered by a gasoline generator and the current is controlled by a commercial power unit to provide pulsed DC current. The pulse frequency and amperage can be controlled at the power unit, and an automatic trip-switch interrupts the power supply unless the person netting the fish at the bow keeps pressure on the switch. Two anodes are suspended from the bow on booms 4 to 6 ft in front of the boat. The boat acts as the cathode. Consult the manufacturer's manual for specific operating instructions. The three-person crew (two netters and the pilot/operator) must wear rubber boots and elbow-length gloves and life preservers.

The boat-mounted electroshocker is run parallel to shore in 1 to 6 ft of water at a slow trolling speed. Fish that are shocked will surface near the anodes and are netted and placed in a live tank in the boat. Each station will be shocked for 15 to 30 minutes, depending upon catch success, and the actual shocking time will be recorded. Fish will be processed at the end of the shocking period according to SOP No. 5.4, Subsection 6.2.5. Water quality parameters will be taken as per Subsection 6.2.6 and data will be collected using the data forms in SOP No. 5.4.

Experimental gill nets 200 to 300 ft long with four to six panels of varying mesh size will be used to sample the deeper portions of reservoirs. Mesh sizes will range from 3/4 in to 2-1/2 in. The gill net will be set on the lake bottom, anchored at each end, and marked with buoys. Each net will be fished from 4 to 12 hours, depending upon catch success and water temperature. The nets will be fished at those time intervals to minimize mortality. Fish will be removed from the net as they are retrieved, and placed in a live box. Fishing duration, water depth, and appropriate water quality parameters will be measured and recorded (SOP No. 5.4). Sample processing and documentation will be completed according to SOP No. 5.4.

TITLE: References

Approved By:

Name (Date) / /

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APPENDIX A. CONCEPTUAL MODEL PATHWAYS

Figures A-1 through A-14 summarize pathways for IHSS 199 through 202, based on the conceptual models for OU 3. The pathways have been numbered to present how each pathway is addressed in the field sampling plan as presented in Tables 5-1 and 6-1 of the work plan. The pathway numbering scheme corresponds to the human health priority pathways presented in Figures 2-14 and 2-16. The pathways summarize the contaminant source, release mechanism, transport medium, secondary release mechanism, exposure route, and receptor.

APPENDIX B. SUMMARY OF RESULTS FROM SAMPLING STATIONS ALONG INDIANA STREET

Tables B-1 through B-7 summarize the analytical results for the sampling locations along Indiana Street. Summaries are provided for groundwater, surface water, and sediments, and are discussed in Subsection 6.2.

TABLE B-1

SUMMARY OF COMPOUNDS DETECTED IN ALLUVIAL GROUNDWATER WELLS ALONG INDIANA STREET

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
VOA–CASE 2						
1,1,1-Trichloroethane	44	1	9	9	200	µg/l
Acetone	36	4	24	14.5		µg/l
Carbon Disulfide	36	1	1	1		µg/l
Methylene Chloride	36	5	24	12.8		µg/l
SEMIVOLTILES–CASE 1						
PESTICIDES/PCBS–CASE 1						
RADIONUCLIDES–CASE 2						
Americium-241	44	42	.800	.031	–	pCi/l
Cesium-137	33	33	.700	.112	–	pCi/l
Curium-244	2	2	.005	.002	–	pCi/l
Gross Alpha–Dissolved	15	15	11.370	4.571	–	pCi/l
Gross Alpha–Suspended	12	12	16.800	3.531	–	pCi/l
Gross Alpha Particle Radioactive	53	51	39.000	10.994	–	pCi/l
Gross Beta–Dissolved	15	15	33.520	7.306	–	pCi/l
Gross Beta–Suspended	5	5	8.286	7.036		pCi/l
Gross Beta Particle Radioactive	60	59	85.000	12.886	–	pCi/l
Plutonium-238	5	5	.016	.007	–	pCi/l
Plutonium-239	30	28	2.100	.224	–	pCi/l
Plutonium-239/240	17	17	1.098	.086	–	pCi/l
Radium-226	9	8	1.200	.549	–	pCi/l
Radium-228	4	3	3.248	2.624	–	pCi/l
Strontium-89, 90	5	5	.854	.499	–	pCi/l
Strontium-90	33	30	2.500	.517	–	pCi/l
Tritium	33	21	290.000	81.551	–	pCi/l
Uranium, Total	27	27	35.700	6.993	–	pCi/l
Uranium-233, -234	45	45	20.000	3.149	–	pCi/l
Uranium-234	2	2	1.400	1.200	–	pCi/l
Uranium-235	33	31	.700	.111	–	pCi/l
Uranium-235/236	11	11	.479	.159	–	pCi/l
Uranium-238	47	47	15.000	2.688	–	pCi/l
INORGANICS–CASE 2						
Aluminum	28	13	.270	.079	.05	mg/l
Antimony	28	3	.197	.091		mg/l
Barium	28	15	.158	.099	1	mg/l
Cadmium	28	1	.0001	.0001	.005	mg/l
Chromium	28	2	.015	.014	.05	mg/l
Copper	28	4	.017	.011	.2	mg/l
Iron	29	14	.282	.101	.3	mg/l
Lead	26	2	.046	.024	.05	mg/l
Lithium	14	5	.685	.176	–	mg/l
Manganese	28	23	.975	.396	.05	mg/l

TABLE B-1

SUMMARY OF COMPOUNDS DETECTED IN ALLUVIAL GROUNDWATER WELLS ALONG INDIANA STREET (Concluded)

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
VOA—CASE 2						
Mercury	27	1	.0002	.0002	.002	mg/l
Molybdenum	28	1	.014	.014	–	mg/l
Nickel	28	9	.25	.101	.2	mg/l
Potassium	27	8	5.1	2.925		mg/l
Selenium	26	8	.039	.020	.01	mg/l
Strontium	28	25	4.74	1.287		mg/l
Tin	12	1	.164	.164	–	mg/l
Vanadium	28	2	.031	.030	–	mg/l
Zinc	28	10	.138	.046	2	mg/l

[1]Average value of detections (nondetects not included in average).
[2]Lowest ARAR identified.

TABLE B-2

SUMMARY OF COMPOUNDS DETECTED IN BEDROCK GROUNDWATER WELLS ALONG INDIANA STREET

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
VOA–CASE 2						
Carbon Disulfide	18	2	3	2.5		µg/l
Methylene Chloride	18	7	24	9.14		µg/l
SEMIVOLATILES–CASE 1						
PESTICIDES–CASE 1						
RADIONUCLIDES–CASE 2						
Americium-241	14	14	.1	.017	–	pCi/l
Cesium-137	5	5	.7	.119	–	pCi/l
Gross Alpha–Dissolved	1	1	16.15	16.15	–	pCi/l
Gross Alpha Particle Radioactive	16	16	170	37.663	–	pCi/l
Gross Beta–Dissolved	1	1	12.9	12.9	–	pCi/l
Gross Beta Particle Radioactive	16	16	220	40.113	–	pCi/l
Plutonium-238	1	1	0	0.000	–	pCi/l
Plutonium-239	14	14	0.30	0.04	–	pCi/l
Plutonium-239/240	1	1	0	0	–	pCi/l
Radium-226	3	3	0.391	0.297	–	pCi/l
Strontium-89, 90	1	1	0.233	0.233	–	pCi/l
Strontium-90	8	6	2.1	0.965	–	pCi/l
Tritium	13	10	330	206.318	–	pCi/l
Uranium, Total	13	13	16.8	11.861	–	pCi/l
Uranium-233, -234	15	15	9.3	6.3	–	pCi/l
Uranium-235	13	13	0.66	0.217	–	pCi/l
Uranium-238	15	15	7.5	4.881	–	pCi/l
INORGANICS–CASE 2						
Aluminum	18	11	426,000	38,727	0.05	mg/l
Antimony	18	2	0.081	0.058		mg/l
Barium	18	16	0.238	0.193	1	mg/l
Cadmium	18	1	0.0001	0.0001	0.005	mg/l
Chromium	18	4	0.018	0.014	0.05	mg/l
Copper	18	6	0.171	0.035	0.2	mg/l
Iron	18	10	1.69	0.275	0.3	mg/l
Lead	17	1	0.002	0.002	0.05	mg/l
Lithium	7	1	0.08	0.08		mg/l

TABLE B-2

SUMMARY OF COMPOUNDS DETECTED IN BEDROCK GROUNDWATER WELLS ALONG INDIANA STREET (Concluded)

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
Manganese	18	11	0.160	0.051	0.05	mg/l
Mercury	17	3	0.0002	0.0002	-0.002	mg/l
Nickel	18	16	0.62	0.157	0.2	mg/l
Potassium	17	10	2.95	2.37		mg/l
Selenium	17	16	0.048	0.020	.01	mg/l
Silver	18	3	0.026	0.020	0.01	mg/l
Strontium	18	18	1.640	1.463		mg/l
Vanadium	18	1	0.024	0.024		mg/l
Zinc	18	7	0.057	0.036	2	mg/l

[1]Average value of detections (nondetects not included in average).
[2]Lowest ARAR identified.

TABLE B-3

SUMMARY OF COMPOUNDS DETECTED IN SURFACE WATER ALONG INDIANA STREET

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
VOA–CASE 2						
Acetone	96	5	19	6	–	µg/l
Benzene	105	1	1	1	0	µg/l
Bromoform	107	1	2	2	–	
Carbon disulfide	95	2	5	3.5	–	µg/l
Chlorobenzene	105	1	1	1	–	µg/l
Ethylbenzene	107	1	1	1	700	µg/l
Methylene chloride	108	15	14	3.61	–	µg/l
Tetrachloroethene	107	2	4	3.5	0	µg/l
Toluene	105	8	6	4.13	2420	µg/l
Trichlorethene	105	3	2	1.7	0	µg/l
Total Xylenes	97	6	6	5	10,000	µg/l
Vinyl acetate	96	1	3	3	–	µg/l
2-butanone	95	3	27	13.7	–	µg/l
1,2-dichloroethane	107	2	4	3.5	0	µg/l
1,1,1-trichloroethane	107	1	4	4	200	µg/l
2-hexanone	95	1	7	7	–	
SEMIVOLATILE–CASE 2						
Bis(2-ethylhexyl)phthalate	29	10	19	6.65	15,000	µg/l
Di-n-butyl-phthalate	29	1	1.6	1.6	–	µg/l
Di-n-octyl-phthalate	29	2	3	2.5	–	µg/l
N-nitrosodiphenylamine	29	1	1	1	4.9	µg/l
PESTICIDES/PCBs–CASE 2						
Atrazine	18	8	2	0.653	3	µg/l
Simazine	17	2	6	3.24	–	µg/l
RADIONUCLIDES–CASE 2						
Americium-241	21	19	0.02	0.004	–	pCi/l
Cesium-137	18	18	0.2	0.013	–	pCi/l
Curium-244	2	2	0.0049	0.002	–	pCi/l
Gross Alpha - Dissolved	11	11	11.01	3.963	–	pCi/l
Gross Alpha - Suspended	9	9	6.5	2.145	–	pCi/l
Gross Alpha Particle Radioactive	29	27	11	3.533	–	pCi/l
Gross Beta - Dissolved	11	11	4.595	3.270	–	pCi/l
Gross Beta - Suspended	5	5	8.286	7.036	–	pCi/l
Gross Beta Particle Radioactive	33	32	9.287	4.676	–	pCi/l

TABLE B-3

SUMMARY OF COMPOUNDS DETECTED IN SURFACE WATER ALONG INDIANA STREET (Concluded)

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
Plutonium-238	1	1	0.0008	0.0008	–	pCi/l
Plutonium-239	12	10	0.06	0.006	–	pCi/l
Plutonium-239/240	10	10	0.0112	0.005	–	pCi/l
Radium-226	4	3	0.3	0.133	–	pCi/l
Strontium-89,90	1	1	0.7982	0.798	–	pCi/l
Strontium-90	19	17	0.7687	0.204	–	pCi/l
Tritium	12	10	230	38.221	–	pCi/l
Uranium, Total	8	8	6	1.816	–	pCi/l
Uranium-233, -234	20	20	3.93	1.307	–	pCi/l
Uranium-234	2	2	1.4	1.2	–	pCi/l
Uranium-235	13	11	0.33	0.050	–	pCi/l
Uranium-235/236	8	8	0.2983	0.099	–	pCi/l
Uranium-238	22	22	3.269	1.215	–	pCi/l
INORGANICS—CASE 2						
Aluminum	83	20	2.14	.394	0.05	mg/l
Arsenic	83	1	0.0021	0.002	0.000002	mg/l
Barium	84	10	0.0991	0.086	1	mg/l
Beryllium	85	1	0.09	0.09	0.0000068	mg/l
Copper	83	7	0.0363	0.025	0.012	mg/l
Cyanide	4	1	0.006	0.006	–	mg/l
Iron	84	36	1.41	0.311	0.3	mg/l
Lead	82	12	0.014	0.005	0.0032	mg/l
Lithium	82	23	0.033	0.016	–	mg/l
Manganese	84	28	0.279	0.057	0.05	mg/l
Mercury	80	5	0.0003	0.0003	0.000012	mg/l
Molybdenum	80	1	0.30	0.30	–	mg/l
Selenium	81	3	0.012	0.007	0.01	mg/l
Silver	82	1	0.02	0.02	0.12	mg/l
Strontium	83	43	0.52	0.344	–	mg/l
Tin	80	4	0.045	0.035	–	mg/l
Vanadium	81	1	0.313	0.313	–	mg/l
Zinc	83	52	0.30	0.054	0.1	mg/l

[1]Average value of detection's (nondetects not included in average).
[2]Lowest ARAR identified.

TABLE B-4

SUMMARY OF COMPOUNDS DETECTED IN SEDIMENTS ALONG INDIANA STREET

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
VOA–CASE 2						
Acetone	11	5	85	122	8,000,000	µg/kg
1,1,1-trichloroethane	11	1	3	3	7,000,000	µg/kg
Toluene	11	1	2	2	20,000,000	µg/kg
Methylene chloride	11	2	90	90	90,000	µg/kg
SEMIVOLATILES–CASE 2						
Bis(2-ethyhexyl)phthalate	11	2	1,000	550	50,000	µg/kg
Fluoranthene	11	1	41	41	–	µg/g
Pyrene	11	1	41	41	–	µg/g
Di-n-butylphthalate	11	1	60	60	–	µg/g
Benzoic acid	11	1	390	390	–	µg/g
4-methylphenol	11	1	2,200	2,200	–	µg/kg
PESTICIDE/PCBs–CASE 2						
Beta-BHC	7	1	1.5	1.5	–	µg/kg
RADIONUCLIDES–CASE 2						
Americium-241	5	5	0.42	0.136	–	pCi/g
Cesium-137	7	7	0.9	0.517	–	pCi/g
Gross Alpha–Dissolved	2	2	11.37	11.02	–	pCi/g
Gross Alpha–Particle Radioactive	4	4	39	28	–	pCi/g
Gross Beta–Dissolved	2	2	33.52	31.75	–	pCi/g
Gross Beta–Particle Radioactive	4	4	36	27.75	–	pCi/g
Plutonium-238	2	2	0.016	0.011	–	pCi/g
Plutonium-239	4	4	1.9	0.908	–	pCi/g
Plutonium-239/240	2	2	1.098	0.687	–	pCi/g
Radium-226	3	3	1.2	1.13	–	pCi/g
Radium-228	3	3	3.248	2.624	–	pCi/g
Strontium-89,90	2	2	0.142	0.128	–	pCi/g
Strontium-90	1	1	-0.4	-0.4	–	pCi/g
Tritium	6	6	205.2	60.807	–	pCi/g
Uranium, Total	4	4	2.7	1.673	–	pCi/g
Uranium-233, -234	6	6	3.048	1.412	–	pCi/g
Uranium-235	3	3	0.086	0.028	–	pCi/g
Uranium-238	6	6	2.215	1.199	–	pCi/g

TABLE B-4

SUMMARY OF COMPOUNDS DETECTED IN SEDIMENTS ALONG INDIANA STREET (Concluded)

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	Potential ARAR[2]	Units
INORGANICS--CASE 2						
Aluminum	11	11	17,600	7,776	–	mg/kg
Arsenic	11	10	4.6	1.92	80	mg/kg
Barium	11	10	157	104.7	4000	mg/kg
Beryllium	11	2	2.3	2.3	0.2	mg/kg
Cadmium	11	1	1.8	1.8	40	mg/kg
Chromium	11	11	17	11.082	–	mg/kg
Cobalt	11	4	8	6.55	–	mg/kg
Copper	11	11	34	16.77	–	mg/kg
Iron	11	11	20,100	15,818	–	mg/kg
Lead	11	11	27.6	16.86	–	mg/kg
Lithium	5	1	8.4	8.4	–	mg/kg
Manganese	11	11	675	284.27	–	mg/kg
Mercury	9	5	0.39	0.252	–	mg/kg
Molybdenum	11	2	11	11.0	–	mg/kg
Nickel	11	8	17.7	13.95	2000	mg/kg
Selenium	11	5	1.3	0.462	–	mg/kg
Silver	11	3	21.2	8.53	200	mg/kg
Strontium	11	8	67	39.68	–	mg/kg
Thallium	5	4	17	11.1	–	mg/kg
Vanadium	11	11	40	32.7	–	mg/kg
Zinc	10	10	391	95.23	–	mg/kg

[1]Average value of detections (nondetects not included in average).
[2]Lowest ARAR identified (proposed RCRA corrective action).

TABLE B-5

SUMMARY OF NONDETECTED PARAMETERS IN ALLUVIAL AND BEDROCK GROUNDWATER WELLS ALONG INDIANA STREET

	Number of Analyses		Number of Analyses
VOA and Semivolatiles		4-Methyl-2-Pentanone	54
		4-Methylphenol	2
1,1,2,2-Tetrachloroethane	54	4-Nitroaniline	2
1,1,2-Trichloroethane	63	4-Nitrophenol	2
1,1-Dichloroethane	54	Acenaphthene	2
1,1-Dichloroethene	63	Acenaphthylene	2
1,2,4-Trichlorobenzene	2	Anthracene	2
1,2-Dichlorobenzene	2	Benzene	54
1,2-Dichloroethane	63	Benzo(a)Anthracene	2
1,2-Dichloroethylene	61	Benzo(a)Pyrene	2
1,2-Dichloropropane	54	Benzo(b)Fluoranthene	2
1,3-Dichlorobenzene	2	Benzo(ghi)Perylene	2
1,4-Dichlorobenzene	2	Benzo(k)Fluoranthene	2
2,4,5-Trichlorophenol	2	Benzoic Acid	2
2,4,6-Trichlorophenol	2	Benzyl Alcohol	2
2,4-Dichlorophenol	2	Bis(2-Chloroethoxy)Methane	2
2,4-Dimethylphenol	2	Bis(2-Chloroethyl)Ether	2
2,4-Dinitrophenol	2	Bis(2-Chloroisopropyl)Ether	2
2,4-Dinitrotoluene	2	Bis(2-Ethylhexyl)Phthalate	2
2,6-Dinitrotoluene	2	Bromodichloromethane	54
2-Butanone	54	Bromoform	54
2-Chloroethyl Vinyl Ether	17	Bromomethane	54
2-Chloronaphthalene	2	Butyl Benzyl Phthalate	2
2-Chlorophenol	2	Carbon Tetrachloride	63
2-Hexanone	54	Chlorobenzene	54
2-Methylnaphthalene	2	Chloroethane	54
2-Methylphenol	2	Chloroform	63
2-Nitroaniline	2	Chloromethane	54
2-Nitrophenol	2	Chrysene	2
3,3´-Dichlorobenzidine	2	Di-n-Butyl Phthalate	2
3-Nitroaniline	2	Di-n-Octyl Phthalate	2
4,6-Dinitro-2-Methylphenol	2	Dibenzo(a,h)anthracene	2
4-Bromophenyl Phenyl Ether	2	Dibenzofuran	2
4-Chloro-3-Methylphenol	2	Dibromochloromethane	54
4-Chloroaniline	2	Diethyl Phthalate	2
4-Chlorophenyl Phenyl Ether	2	Dimethyl Phthalate	2

TABLE B-5

SUMMARY OF NONDETECTED PARAMETERS IN ALLUVIAL AND BEDROCK GROUNDWATER WELLS ALONG INDIANA STREET (Continued)

	Number of Analyses		Number of Analyses
Ethylbenzene	54	Aroclor-1016	2
Fluoranthene	2	Aroclor-1221	2
Fluorene	2	Aroclor-1232	2
Hexachlorobenzene	2	Aroclor-1242	2
Hexachlorobutadiene	2	Aroclor-1248	2
Hexachlorocyclopentadiene	2	Aroclor-1254	2
Hexachloroethane	2	Aroclor-1260	2
Indeno(1,2,3-cd)Pyrene	2	Chlordane	2
Isophorone	2	Dieldrin	2
N-Nitroso-Di-n-Propylamine	2	Endosulfan I	2
N-Nitrosodiphenylamine	2	Endosulfan II	2
Naphthalene	2	Endosulfan Sulfate	2
Nitrobenzene	2	Endrin	2
Pentachlorophenol	2	Endrin Ketone	2
Phenanthrene	2	Heptachlor	2
Phenol	2	Heptachlor Epoxide	2
Pyrene	2	Methoxychlor	2
Styrene	54	Parathion, Ethyl	2
Tetrachloroethene	63	Toxaphene	2
Toluene	54	alpha-BHC	2
Total Xylenes	53	beta-BHC	2
Trichloroethene	63	delta-BHC	2
Vinyl Acetate	54	gamma-BHC (Lindane)	2
Vinyl Chloride	54		
cis-1,3-Dichloropropene	54	**Radionuclides**	
trans-1,2-Dichloroethene	9		
trans-1,3-Dichloropropene	54	Strotium-89	2
Pesticides/PCBs		**Inorganics**	
4,4´-DDD	2	Arsenic	43
4,4´-DDE	2	Beryllium	46
4,4´-DDT	2	Cesium	43
Aldrin	2	Chromium	46

TABLE B-5

SUMMARY OF NONDETECTED PARAMETERS IN ALLUVIAL AND BEDROCK GROUNDWATER WELLS ALONG INDIANA STREET (Concluded)

	Number of Analyses		Number of Analyses
Cobalt	46		
Cyanide	7		
Thallium	43		

TABLE B-6

SUMMARY OF NONDETECTED PARAMETERS IN SURFACE WATER SAMPLES ALONG INDIANA STREET

	Number of Analyses		Number of Analyses
VOA and Semivolatiles		3-Nitroaniline	29
		4,6-Dinitro-2-Methylphenol	29
1,1,1,2-Tetrachloroethane	11	4-Bromophenyl Phenyl Ether	29
1,1,2,2-Tetrachloroethane	108	4-Chloro-3-Methylphenol	29
1,1,2-Trichloroethane	107	4-Chloraniline	29
1,1-Dichloroethane	107	4-Chlorophenyl Phenyl Ether	29
1,1-Dichloroethene	105	4-Methyl-2-Pentanone	95
1,1-Dichloropropene	12	4-Methylphenol	29
1,2,3-Trichlorobenzene	12	4-Nitroaniline	29
1,2,3-Trichloropropane	12	4-Nitrophenol	29
1,2,4-Trichlorobenzene	41	Acenaphthene	37
1,2-Dibromoethane	12	Anthracene	37
1,2-Dichlorobenzene	41	Benzenamine	4
1,2-Dichloroethylene	94	Benzene, 1,2,4-Trimethyl	12
1,2-Dichloropropane	107	Benzene, 1,3,5-Trimethyl	12
1,2-Dimethylbenzene	45	Benzidine	14
1,3-Dichlorobenzene	41	Benzo(a)Anthracene	37
1,3-Dichloropropane	12	Benzo(a)Pyrene	37
1,3-Dimethylbenzene	12	Benzo(b)Fluoranthene	37
1,4-Dichlorobenzene	41	Benzo(ghi)Perylene	37
2,4,5-Trichlorophenol	29	Benzo(k)Fluoranthene	37
2,4,6-Trichlorophenol	29	Benzoic Acid	29
2,4-Dichlorophenol	29	Benzyl Alcohol	29
2,4-Dimethylphenol	29	Bis(2-Chloroethoxy)methane	29
2,4-Dinitrophenol	29	Bis(2-Chloroethyl)ether	29
2,4-Dinitrotoluene	29	Bis(2-Chloroisopropyl)ether	29
2,6-Dinitrotoluene	29	Bromobenzene	12
2-Chlororethyl Vinyl Ether	46	Bromochloromethane	11
2-Chloronaphthalene	29	Bromodichloromethane	107
2-Chlorophenol	29	Bromomethane	107
2-Methylnaphthalene	29	Butyl Benzyl Phthalate	29
2-Methylphenol	29	Carbon Tetrachloride	107
2-Nitroaniline	29	Chloroethane	107
2-Nitrophenol	29	Chloroform	107
2-Propenenitrile	12	Chloromethane	107
3,3´-Dichlorobenzidine	29	Chrysene	37

TABLE B-6

SUMMARY OF NONDETECTED PARAMETERS IN SURFACE WATER SAMPLES ALONG INDIANA STREET (Continued)

	Number of Analyses		Number of Analyses
Cumene	12	o-Chlorotoluene	12
Dibenzo(a,h)anthracene	37	p-Chlorotoluene	12
Dibenzofuran	29	p-Cymene	12
Dibromochloromethane	104	p-Xylene	11
Dibromomethane	12	sec-Butylbenzene	12
Dichlorodifluoromethane	12	sec-Dichloropropane	12
Diethyl Phthalate	29	tert-Butylbenzene	12
Dimethyl Phthalate	29	trans-1,2-Dichloroethene	13
Fluoranthene	37	trans-1,3-Dichloropropene	107
Fluorene	37		
Hexachlorobenzene	29	**Pesticide/PCBs**	
Hexachlorobutadiene	41		
Hexachlorocyclopentadiene	29	2,2-Dichloropropanoic Acid	11
Hexachloroethane	29	2,4,5-Trichlorophenoxyacetic	11
Indeno(1,2,3-cd)Pyrene	37	2,4-DB	11
Isophorone	29	2,4-Dichlorophenoxyacetic AC	11
N-Nitroso-di-N-propylamine	29	4,4´-DDD	28
N-Nitrosodi-N-Butylamine	10	4,4´-DDE	28
N-Nitrosodiethylamine	10	4,4´-DDT	28
N-Nitrosodimethylamine	14	Aldrin	28
N-Nitrosopyrrolidine	10	Ametryn	17
Naphthalene	49	Aroclor-1016	28
Nitrobenzene	29	Aroclor-1221	28
Pentachlorophenol	29	Aroclor-1232	28
Phenanthrene	37	Aroclor-1242	28
Phenol	29	Aroclor-1248	28
Propane, 1,2-Dibromo-3-Chloro	12	Aroclor-1254	28
Pyrene	37	Aroclor-1260	28
Styrene	107	Atraton	4
Trichlorofluoromethane	12	Atrazine	18
Vinyl Chloride	107	Chlordane	12
cis-1,2-Dichloroethene	12	Cyanazine	13
cis-1,3-Dichloropropene	107	Dicamba	11
n-Butylbenzene	12	Dichlorprop	11
n-Propylbenzene	12	Dieldrin	28

TABLE B-6

SUMMARY OF NONDETECTED PARAMETERS IN SURFACE WATER SAMPLES ALONG INDIANA STREET (Concluded)

	Number of Analyses		Number of Analyses
Endosulfan I	28	**Inorganics**	
Endosulfan II	28		
Endosulfan Sulfate	28	Antimony	81
Endrin	28	Cadmium	77
Endrin Aldehyde	6	Cesium	93
Endrin Ketone	17	Chromium	81
Heptachlor	28	Cobalt	81
Heptachlor Epoxide	28	Cyanides (soluble salts)	2
MCPA	11	Hexavalent Chromium	7
MCPP	11	Nickel	81
Methoxychlor	17	Thallium	81
Parathion, Ethyl	1		
Phenol, 2-(1-Methylpropyl)-4	11		
Prometon	17		
Prometryn	17		
Propanoic Acid, 2-(2,4,5-Tri	11		
Propazine	17		
Simazine	17		
Simetryn	17		
Terbuthylazine	17		
Terbutryn	4		
Toxaphene	28		
alpha-BHC	28		
alpha-Chlordane	16		
beta-BHC	28		
delta-BHC	28		
gamma-BHC (Lindane)	28		
gamma-Chlordane	16		
Radionuclides			
Strontium-89	2		

TABLE B-7

SUMMARY OF NONDETECTED PARAMETERS IN SEDIMENTS ALONG INDIANA STREET

	Number of Analyses		Number of Analyses
VOA and Semivolatiles		4-Chlorophenyl Phenyl Ether	11
		4-Methyl-2-Pentanone	11
1,1,1,2-Tetrachloroethane	11	4-Nitroaniline	11
1,1,2-Trichloroethane	11	4-Nitrophenol	11
1,1-Dichlororethane	11	Acenaphthene	11
1,1-Dichloroethene	11	Acenaphthylene	11
1,2,4-Trichlorobenzene	11	Acetone	11
1,2-Dichlorobenzene	11	Anthracene	11
1,2-Dibromoethane	11	Benzene	11
1,2-Dichloroethene	2	Benzo(a)Anthracene	11
1,2-Dichloroethylene	5	Benzo(a)Pyrene	11
1,2-Dichloropropane	11	Benzo(b)Fluoranthene	11
1,3-Dichlorobenzene	11	Benzo(ghi)Perylene	11
1,4-Dichlorobenzene	11	Benzyl Alcohol	11
2,4,5-Trichlorophenol	11	Bis(2-Chloroethoxy)methane	11
2,4,6-Trichlorophenol	11	Bis(2-Chloroethyl)ether	11
2,4-Dichlorophenol	11	Bis(2-Chloroisopropyl)ether	11
2,4-Dimethylphenol	11	Bromodichloromethane	11
2,4-Dinitrophenol	11	Bromoform	11
2,4-Dinitrotoluene	11	Bromomethane	11
2,6-Dinitrotoluene	11	Butyl Benzyl Phthalate	11
2-Butanone	11	Carbon Disulfide	11
2-Chloroethyl Vinyl Ether	4	Carbon Tetrachloride	11
2-Chloronaphthalene	11	Chlorobenzene	11
2-Chlorophenol	11	Chloroethane	11
2-Hexanone	11	Chloroform	11
2-Methylnaphthalene	11	Chloromethane	11
2-Methylphenol	11	Chrysene	11
2-Nitroaniline	11	Di-n-Octyl Phthalate	11
2-Nitrophenol	11	Dibenzo(a,h)Anthracene	11
3,3´-Dichlorobenzidine	11	Dibenzofuran	11
3-Nitroaniline	11	Dibromochloromethane	11
4,6-Dinitro-2-Methylphenol	11	Diethyl Phthalate	11
4-Bromophenyl Phenyl Ether	11	Dimethyl Phthalate	11
4-Chloro-3-Methylphenol	11	Ethylbenzene	11
4-Chloraniline	11	Fluorene	11

TABLE B-7

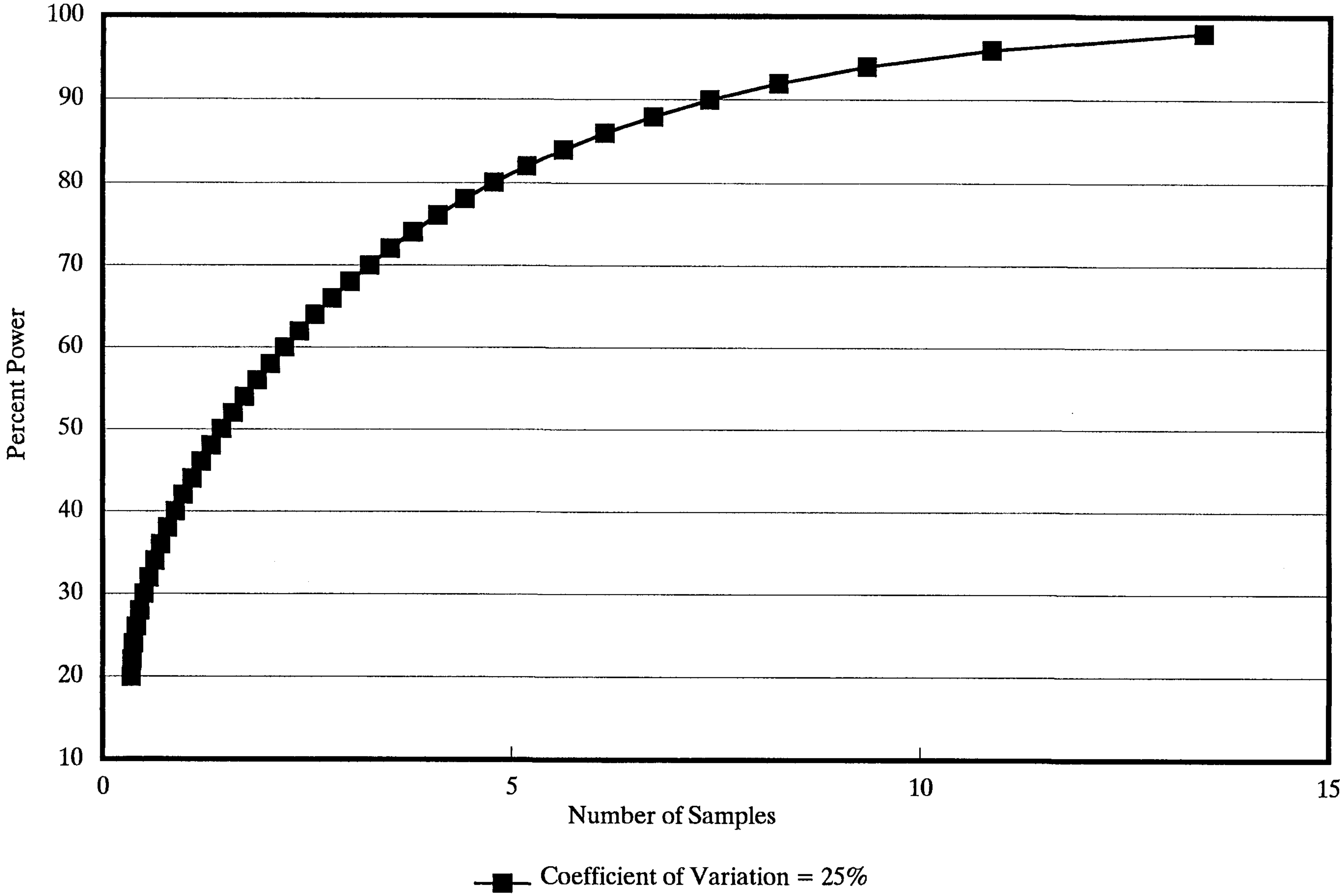
SUMMARY OF NONDETECTED PARAMETERS IN SEDIMENTS ALONG INDIANA STREET (Concluded)

	Number of Analyses		Number of Analyses
Hexachlorobenzene	11	Aroclor-1248	7
Hexachlorobutadiene	11	Aroclor-1254	7
Hexachlorocyclopentadiene	11	Aroclor-1260	7
Hexachloroethane	11	Chlordane	3
Indeno(1,2,3-cd)pyrene	11	Chloride	3
Isophorone	11	Cyanide	4
N-Nitroso-Di-n-Propylamine	11	Dieldrin	7
N-Nitrosodiphenylamine	11	Endosulfan I	7
Naphthalene	11	Endosulfan II	7
Nitrobenzene	11	Endosulfan Sulfate	7
Pentachlorophenol	11	Endrin	7
Phenanthrene	11	Endrin Ketone	7
Phenol	11	Heptachlor	7
Styrene	11	Heptachlor Epoxide	7
Tetrachloroethene	11	Methoxychlor	7
Total Xylenes	11	Toxaphene	7
Trichloroethene	11	alpha-BHC	7
Vinyl Acetate	11	alpha-Chlordane	4
Vinyl Chloride	11	delta-BHC	7
cis-1,2-Dichloropropene	11	gamma-BHC (Lindane)	7
trans-1,2-Dichloroethene	4	gamma-Chlordane	4
trans-1,3-Dichloropropene	11		
		Radionuclides	
Pesticide/PCBs			
		None	
4,4´-DDD	7		
4,4´-DDE	7	**Inorganics**	
4,4´-DDT	7		
Aldrin	7	Antimony	11
Alkalinity as $CaCO_3$	2	Cesium	9
Aroclor-1016	7	Tin	5
Aroclor-1221	7		
Aroclor-1232	7		
Aroclor-1242	7		

APPENDIX C. POWER CURVES BASED ON HISTORICAL DATA

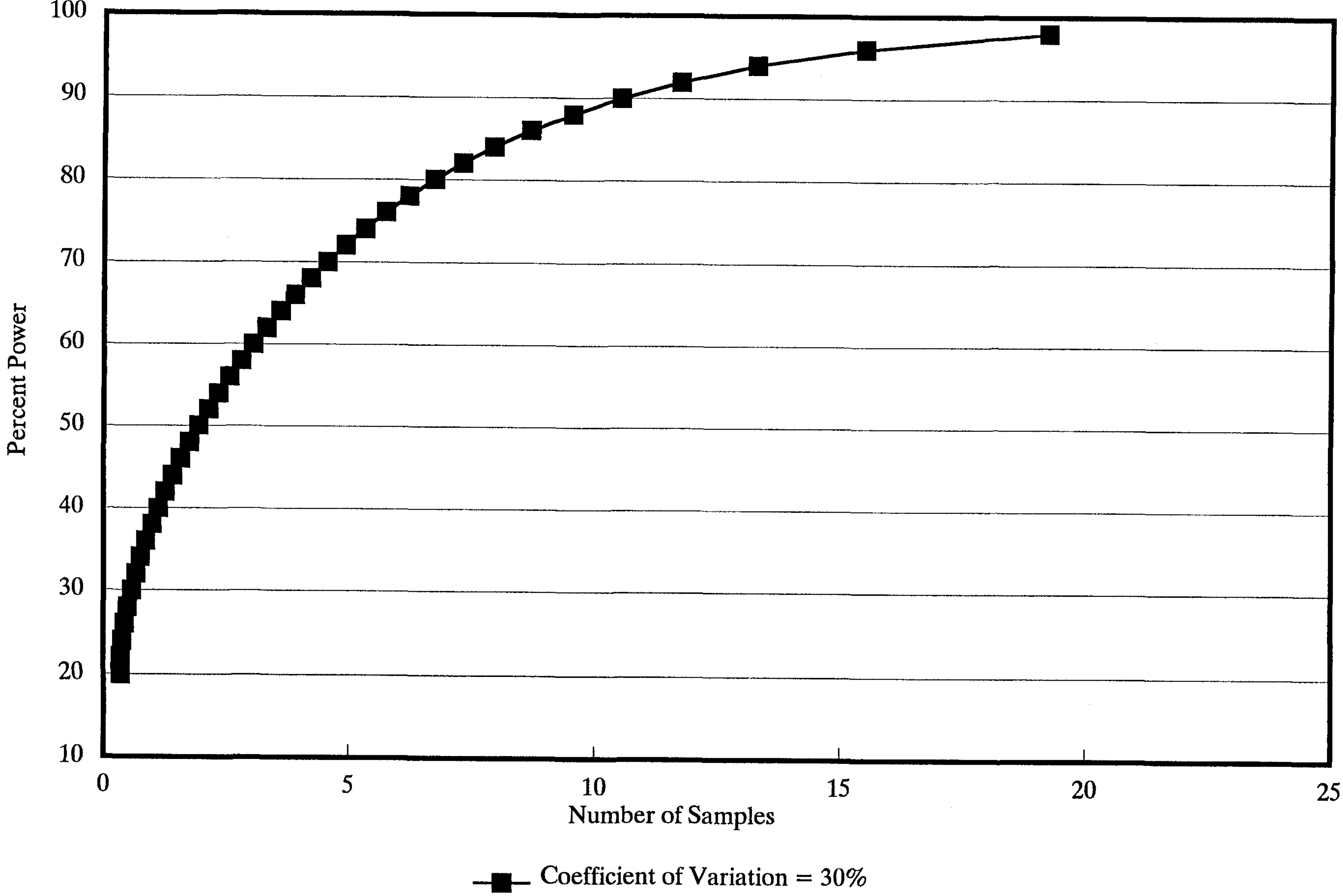
Power curves have been generated for sediments in Woman Creek, Mower Ditch, Walnut Creek, Great Western Reservoir, and Standley Lake. A power curve was also developed for surfacial soils in OU 3. The power curves generated are based on an 80 percent confidence and minimum detectable difference of 20 percent. The power curves were used to develop the statistical approach to the OU 3 FSP (Subsection 6.3.1).

SAMPLE SIZE CALCULATION FOR SEDIMENTS IN WOMAN CREEK
Using Historical Plutonium 239/240 Data



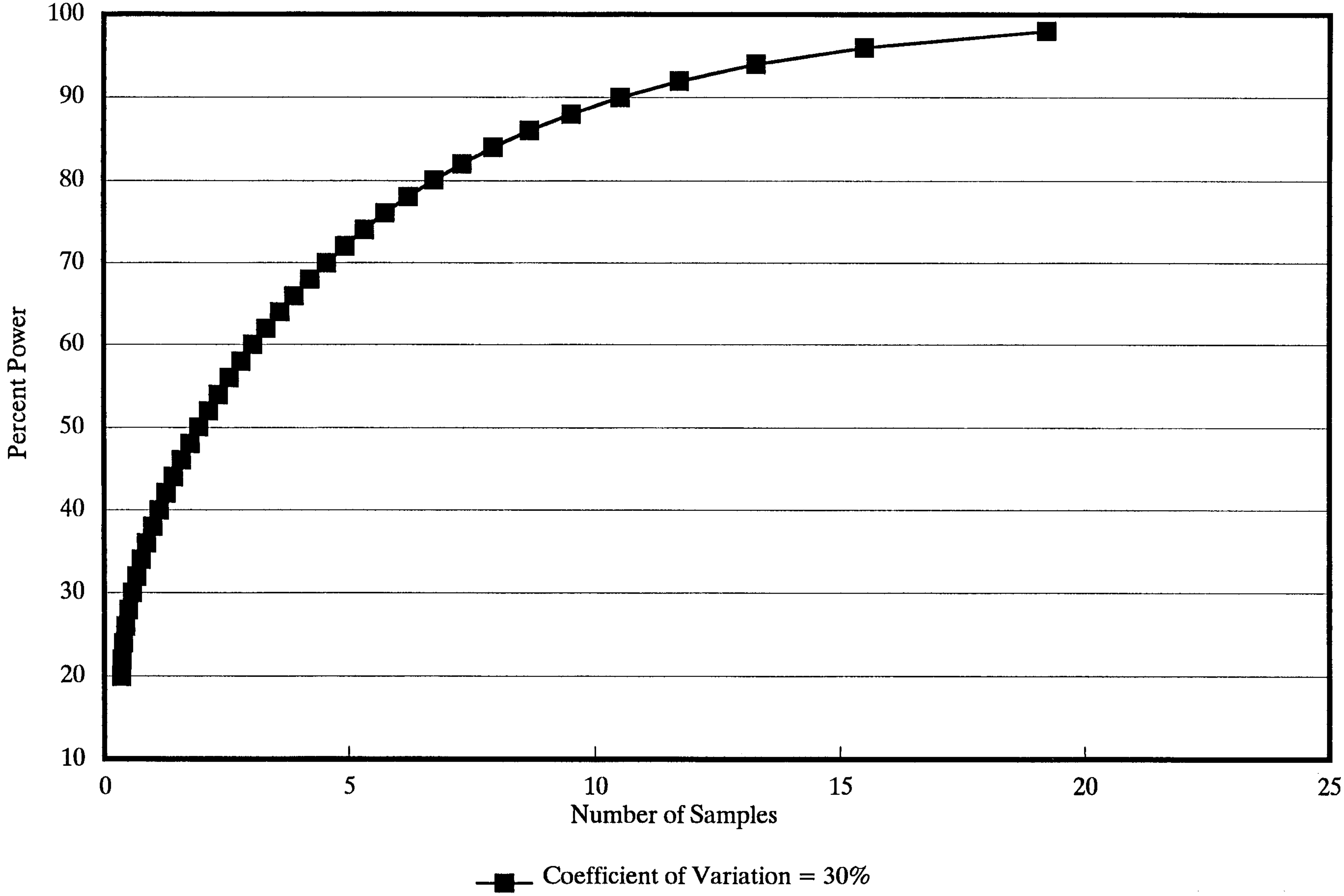
Power Curve with confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistics: Mean = 0.834 pCi/g, Standard Deviation = 0.209 pCi/g, CV = Standard Deviation/Mean.

SAMPLE SIZE CALCULATION FOR SEDIMENTS IN MOWER DITCH
Using Historical Plutonium 239/240 Data



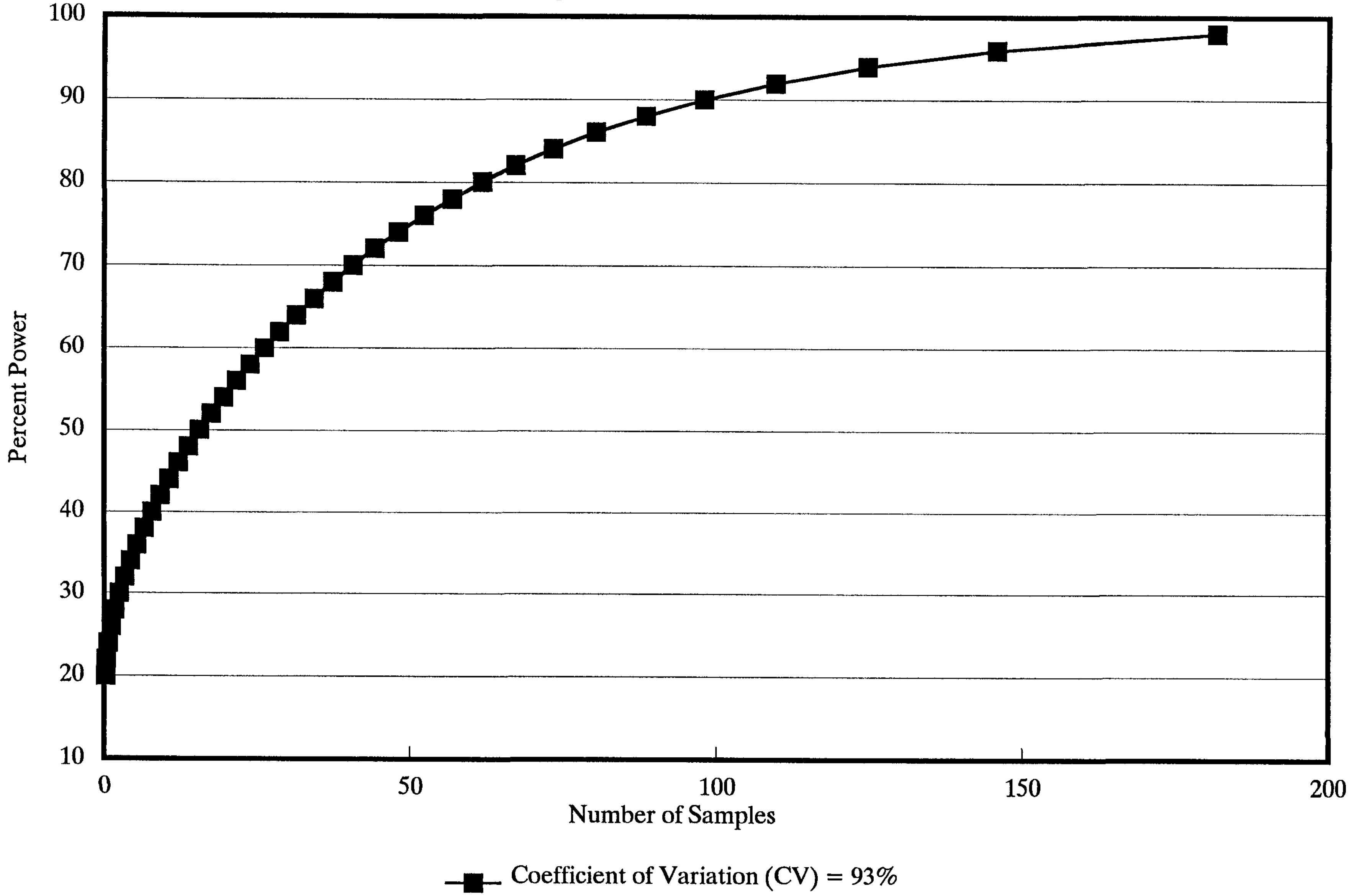
Power Curve with confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistics: Mean = 0.422 pCi/g, Standard Deviation = 0.126 pCi/g, CV = Standard Deviation/Mean.

SAMPLE SIZE CALCULATION FOR SEDIMENTS IN WALNUT CREEK
Using Historical Plutonium 239/240 Data



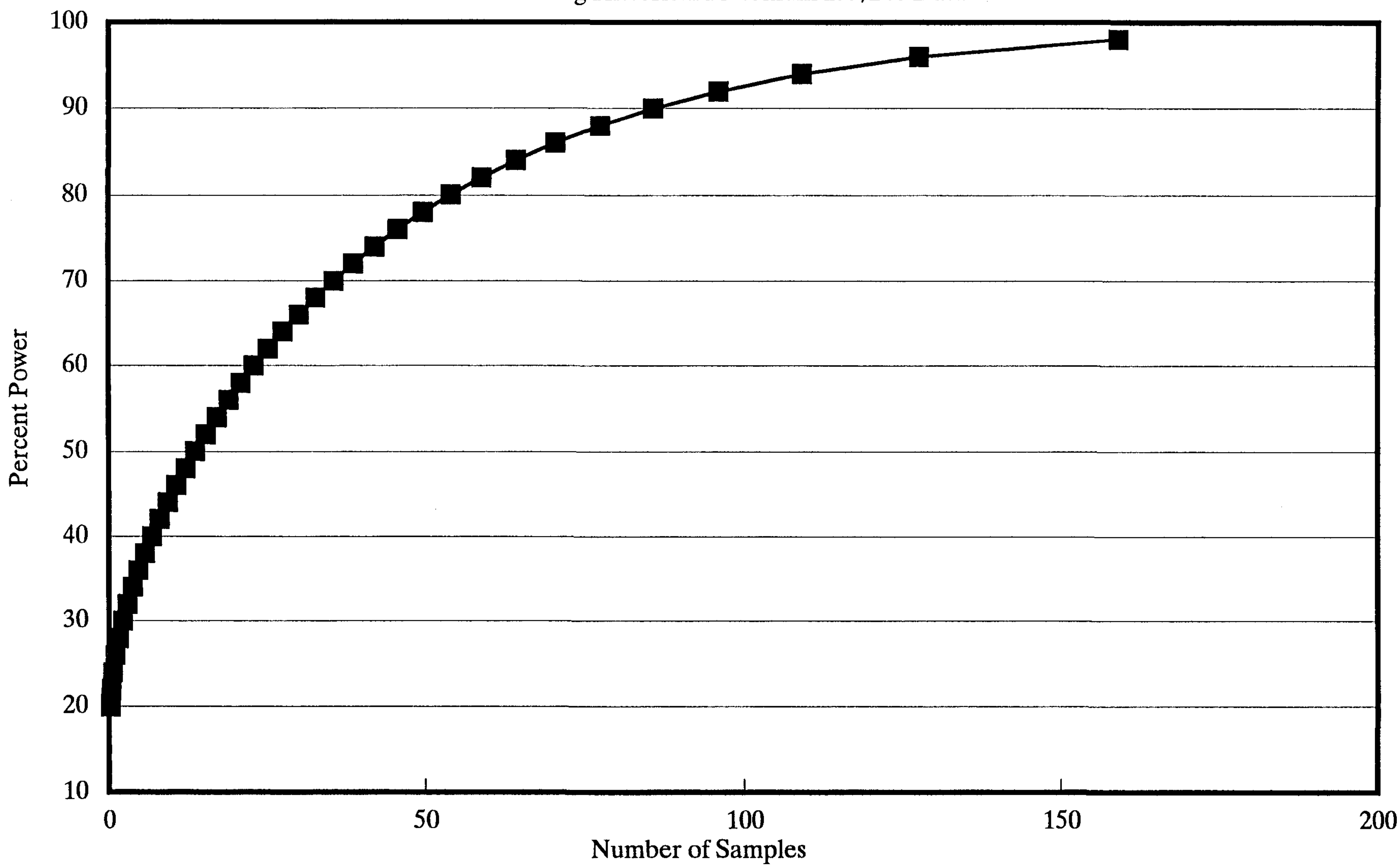
Power Curve with confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistics: No Historical Data Available, Assuming Largest CV found in other Drainages.

SAMPLE SIZE CALCULATION FOR SEDIMENTS IN GREAT WESTERN RESERVOIR
Using Historical Plutonium 239/240 Data



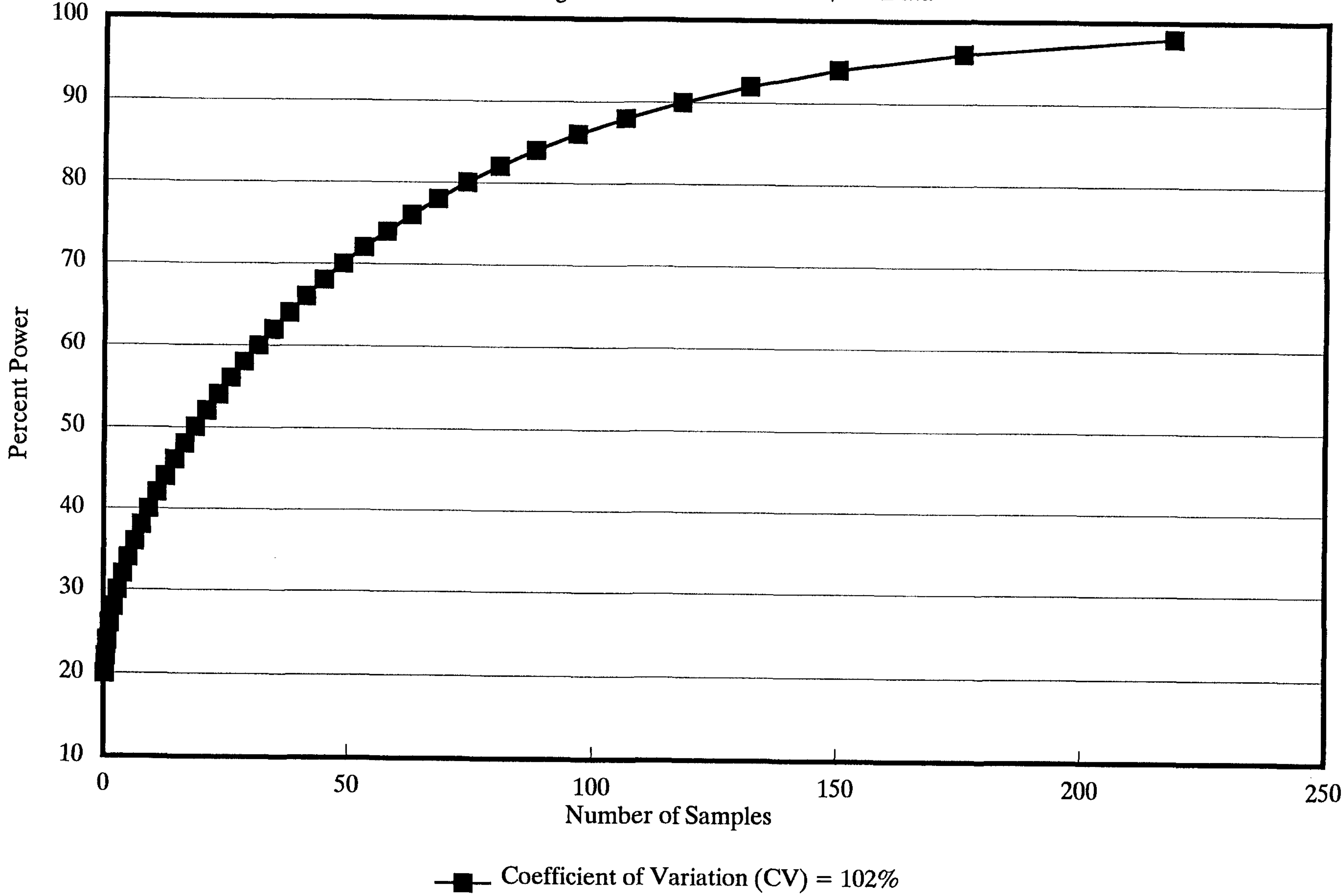
Power Curve with Confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistics: Mean = 0.170 pCi/g, Standard Deviation = 0.158 pCi/g, CV = Standard Deviation/Mean.

SAMPLE SIZE CALCULATION FOR SEDIMENTS IN STANDLEY LAKE
Using Historical Plutonium 239/240 Data



Power Curve with Confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistics: Mean = 0.031 pCi/g, Standard Deviation = 0.027 pCi/g, CV = Standard Deviation/Mean.

SAMPLE SIZE CALCUATION FOR SURFICIAL SOILS IN OPERABLE UNIT 3
Using Historical Plutonium 239/240 Data



Power Curve with Confidence equal to 80% and Detectable Difference equal to 20%
Historical Statistic: Mean = 0.998 pCi/g, Standard Deviation = 1.02 pCi/g, CV = Standard Deviation/Mean.

APPENDIX D. THE DESIGN OF OPTIMAL STRATEGY FOR SAMPLING PLUTONIUM AND AMERICIUM IN SOILS OF THE OPERATIONAL UNIT NO. 3

INTRODUCTION

More than 120 soil samples were collected and analyzed for plutonium concentrations in surficial soils east of Indiana Street. Most of these analyses were performed during 1971, and 1975 to 1978. All of the soil samples were taken from the top soil horizons (0 to 5 cm) using a modified Health and Safety Laboratory (HASL) technique, also known as the Rocky Flat soil sampling protocol. This soil sampling technique is described in detail in SOP GT 70. This previous sampling effort provides excellent data to assess the spatial dependency of plutonium in the soils east of the RFP. Recent study in soils east of 903 Pad showed linear relationships between americium (Am) and plutonium (Pu) (Am = Pu/6.23). This estimate takes into account the original isotope mix and mixture age (EG&G, 1991). Hence, the existing information can be used to construct a semi-variogram for designing optimal sampling strategy for plutonium and americium in soils east of RFP.

Plutonium concentration in soils collected in 1971 were somewhat higher than those collected in 1976 through 1977 (Table D-1). This difference is probably resulted from the remedial activities performed immediately east of Indiana Street during 1976 as well as typical heterogeneity of plutonium distribution in the soil environment. For the purpose of the spatial analysis of actinides in the soils east of the RFP, the difference between the two sampling periods was considered negligible and the data being kriged was considered a single population. Moreover, the larger number of observations makes the spatial analysis more robust and less prone to computational instability due to outliers.

TABLE D-1

SUMMARY OF PLUTONIUM CONCENTRATION IN SOILS EAST OF INDIANA STREET

Year	Number of Samples	Mean	S.D.
1971	46	1.49	1.63
1976 through 1977	74	0.76	1.07

GEOSTATISTICAL APPROACH

The use of the regionalized variable theory and the semi-variogram as means of describing spatial variation in soils was demonstrated by numerous authors (e.g., Burgess and Webster, 1980a, 1980b; Webster and McBratney, 1981; McBratney et al. 1981; Burgess et al., 1981; Gilbert and Simpson, 1985). The semi-variogram describes the rate of change in a regionalized variable and measures the degree of spatial dependence between samples within geographical boundaries (two-dimension analysis) and/or with depth (three-dimension analysis). The spatial structure of the regionalized variable can be described by the semi-variogram in the case of stationary conditions (Bregt et. al. 1991). The variogram splits the total variance in a data set into two parts. The first part represents the spatial variance between samples values relative to the distance between samples, whereas the second represents local, or random variance. Because the semi-variogram is a function of distance, the weights change according to the geographical arrangement of the samples (Isaaks and Srivastava, 1989). Hence, the semi-variogram can provide the maximum sample separation distance for optimal soil sampling design for OU 3. Optimum sampling for the purpose of this report is defined as the statistically objective determination of a distance between samples that achieves the desired precision.

By definition, the value of the theoretical variogram $\tau(h)$ for a given distance h, is the square of the expected difference between the values of the samples separated by distance h:

$$\tau(h) = E\{z(x) - z(x + h)\}^2 \qquad (1)$$

where z(x) and z(x + h) are the values of plutonium at locations x and x + h separated by the vector h, known as the lag. The experimental semi-variogram can be estimated from the data at hand by:

$$\tau(h) = \frac{1}{n(h)} \sum_{i=1}^{n(h)} [z(x_i) - z(x_i + h)]^2 \qquad (2)$$

Thus, for a given distance h, the values of all samples which are separated by h are subtracted from each other, and the result squared, accumulated and divided by the number of pairs found. This gives one point on the semi-variogram. The distance h is increased and the process is repeated with a specified direction. A horizontal half window of 90 degrees will effectively cover the entire plane, and is defined as isotropic semi-variogram.

Modeling the experimental semi-variogram provides the necessary parameters (i.e., nugget, sill, and range) for interpolation of soil-plutonium concentrations. The calculated variance $\tau(h)$ between samples increases with increasing separation distances up to a distance (a), called the range, where it levels off to a constant value. Samples with separation distance less than the range are spatially correlated, and those with separation distances greater than the range are statistically independent. The point in which the semi-variogram levels off called the sill, and is equal to the overall variance of the sample population. The sill is composed of two components, C and C_0. In most soil studies $\tau(h)$ will remain nonzero as h approaches zero, which is called the nugget effect ($\tau(h) = C_0$, $h > 0$). It reflects the inherent random variation of a contaminant dispersion in the environment that cannot be predicted by any method (Clark, 1979), the variability between sampling points at distance less than that actually used or available, analytical error, and samples collected from different populations (depths, soil type, and other edaphic factors).

The interpolation procedure known as kriging uses the information from the semi-variogram to find an optimal set of weights that are used in the estimation of the surface at unsampled locations. The kriging procedure is optimal in the sense that it provides estimates with minimum variance or error, and this variance can itself be estimated with certain degree of confidence. The main sources of the error estimates are: (1) number of the nearby samples, (2) proximity of the available samples, (3) spatial arrangement, and (4) the nature of the contaminant.

Kriging can be applied globally or locally. A global application would be to use the data over the entire site and estimate the mean for the site. In soil studies, it is usually preferable to use a local estimator, which means calculating the average value of the regionalized variable over soil blocks (areas) from which a sample was collected. For example, the kriging estimator of the plutonium level at a point x_0 in geographical space is:

$$z(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i) \qquad (3)$$

where $z(x_i)$ is the observed datum at the point x_i within the local neighborhood about the point x_0, and λ_i is the weight attached to that datum as obtained using ordinary kriging. If the assumptions underlying ordinary kriging are met, then the kriging estimator is a best linear unbiased estimator (BLUE). By using local estimation, there is no need to assume the same mean and covariance function over the entire study site.

Weighted moving average methods are based on the intuitive notion that the data values closest to the block where the average is calculated should receive more weight than more distant points. One problem with these methods is determining the appropriate weighting function. Inverse distance or square inverse distance weighting are often used, but it is difficult to know which function is best. Although kriging is a weighted moving average, its weights λ_i are determined using the semi-variogram, which assures that the kriging estimator is BLUE. Moreover, clustered data does not introduce a bias if kriging is used because kriging takes into account the spatial arrangement of the data. In addition, kriging permits one to estimate the variance of each estimated mean and, hence, to assess whether additional data are needed in a given area. The semi-variogram calculations and the block kriging computations were performed by the GEO-EAS program (Englund and Sparks, 1988).

The traditional method of mapping (hand-contouring or computer-generated map) usually produces smooth contours that honor the data at known points. This technique usually produces a fairly erratic contours. Geostatistical techniques will produce a much smoother map that shows the general trend of a given pollutant. A cross section through the traditional map will show the up and down necessary to fit a smooth curve through the data, whereas the kriged section line will show a broad general trend and differs from the data by an average amount corresponding to the nugget effect. Hence, one should not expect to see a kriged contoured map that precisely matches all of the observed points, but the best unbiased estimate of the general trend of plutonium and americium in the soil environment east of the RFP.

SPATIAL DISTRIBUTION OF PLUTONIUM EAST OF ROCKY FLATS PLANT

The soil-plutonium concentrations in soils east of Indiana Street are depicted in Figure D-1. The soil-plutonium distribution is highly skewed with large coefficient of variation (Figure D-2). A coefficient of variation greater than 100 percent indicates the presence of some few high sample values that may have a significant impact on the final estimates. Most spatial estimation techniques perform better if the distribution of data values is close to normal distribution. To achieve this end, the data was transformed using ln(X) function, which greatly reduced the skewness and improved the coefficient of variation (Figure D-3). Because of the data transformation, lognormal kriging was performed. This involved estimating the semi-variogram and performing all the kriging calculations on the transformed data. Transforming the logarithmic kriging estimates back to the original scale gives estimates of median concentrations (Gilbert and Simpson, 1985). To backtransform the data to the original unit of concentrations in terms of mean concentrations, the following equation was employed:

$$Z_i = e^{[\ln Y_i + \frac{1}{2}\sigma^2_{ki}]} \qquad (4)$$

where Z_i= is the backtransform value for block i, Y_i is the log-kriged estimate, σ^2_{ki} is the kriging variance for the block estimate. The kriging variance for the block estimate was computed using the following equation:

$$\sigma^2_k = 2\sum_{i=1}^{n} \lambda_i \gamma(x_i - x_{i+h}) - \sum_{i=1}^{n} \sum_{j=1}^{n} \lambda_i \lambda_j \gamma(x_i - x_j) \quad (5)$$

where $\gamma(x_i - x_{i+h})$ and $\gamma(x_i - x_j)$ are the values of the semi-variance between $x_i - x_{i+h}$ and $x_i - x_j$ respectively. The square root of the kriging variance is analogous to the standard error of classical statistics. The weights λ_i and the kriging variance σ^2_k do not depend on the observed data values, but only on the semi-variogram and the distance h. This is why it is possible to compute the kriging variance for different sampling network designs and get a better notion of the trade offs between costs of sampling and benefits, in terms of smaller kriging variance (optimal grid sampling).

If the spatial distribution of soil-plutonium along the west-east transect from the 903 Pad followed the regionalized variable theory, then samples taken close to one another will, on average, be more similar than samples taken far apart. Thus, the longer the distances over which predictions are made the less reliable they are. The semi-variogram computation suggests an exponential model with nugget of 0.02, sill of 0.14 and a range of 1650 m (Figure D-4). The exponential model was computed using the following formula:

$$\tau(h) = C_0 + C\{1 - \exp(h/a)\} \quad (6)$$

where

h = lag interval,
C_0 = nugget variance
C = sill
A_0 = range.

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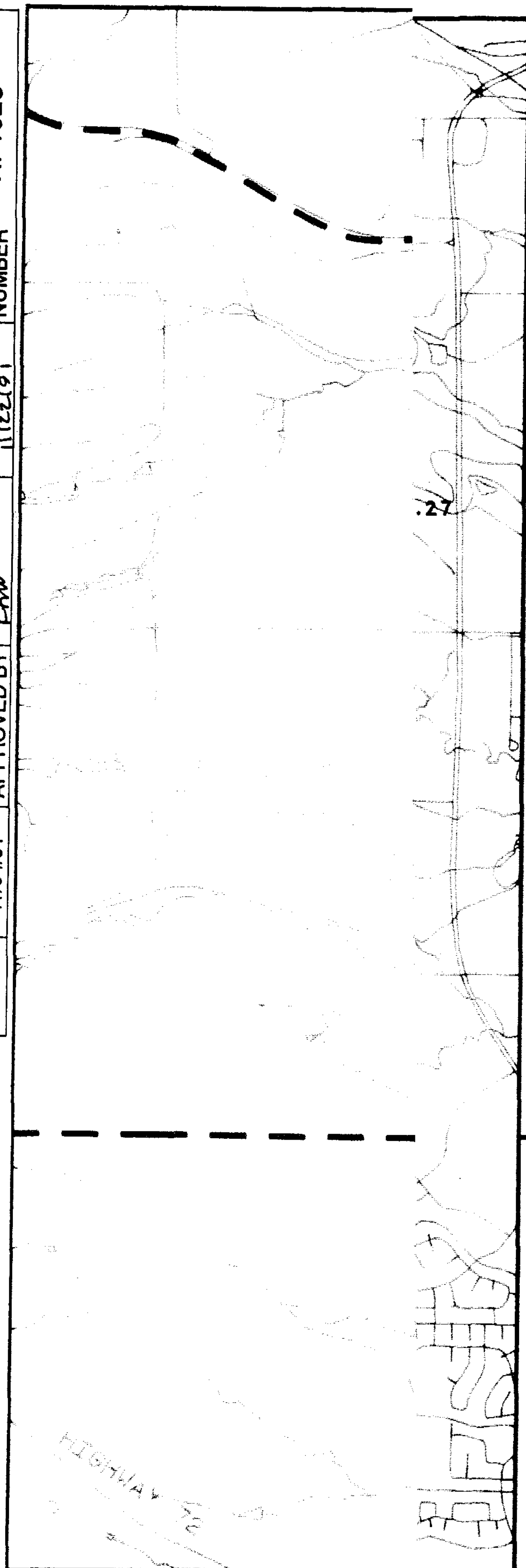
Douville 11/04/91	A. Lange 11/05/91	11/22/91	RF1023



MAP LEGEND

CONTOURS OF SOIL-PU CONCENTRATIONS (pCi/g)

ROCKY FLATS PLANT BOUNDARY

APPROXIMATE SAMPLE LOCATIONS AND VALUES (pCi/g)

0 feet 1725 3450

U.S. DEPARTMENT of ENERGY

Rocky Flats Plant
Golden, Colorado

Figure D-1
Kriging Estimates for Plutonium Levels in Soils East of Indiana Based on 1971, 1975 - 1978 Studies

DRAWN BY Douville 6/19/91

CHECKED BY A. Lang 6/22/91

APPROVED BY PBS 6/20/91

DRAWING NUMBER RF013

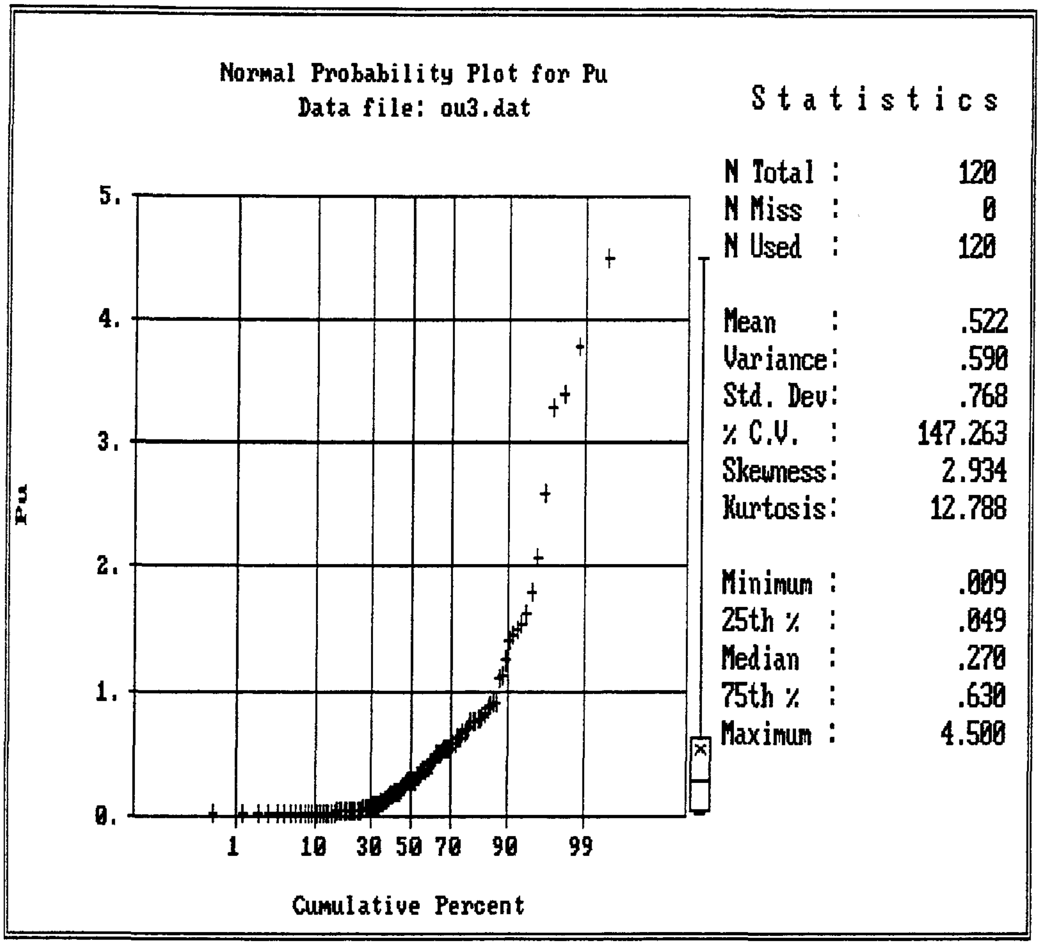
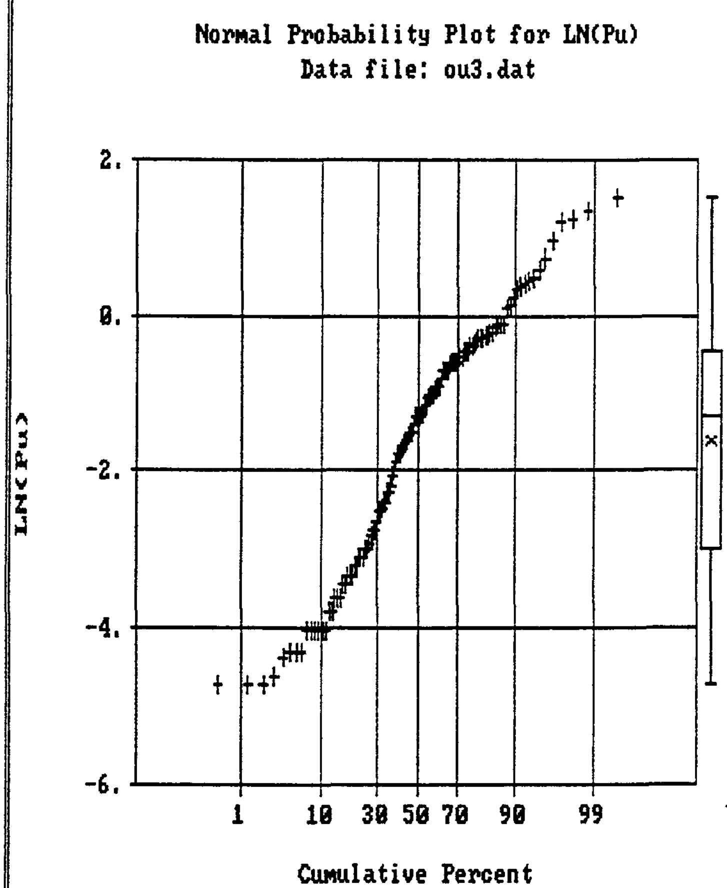


Figure D-2

Normal Probability Plot for Pu Concentrates (Pu/g) in Soils East of Indiana Street



Statistics

N Total :	120
N Miss :	0
N Used :	120
Mean :	-1.628
Variance:	2.487
Std. Dev:	1.577
% C.V. :	96.868
Skewness:	-.253
Kurtosis:	2.097
Minimum :	-4.711
25th % :	-3.006
Median :	-1.309
75th % :	-.462
Maximum :	1.504

Figure D-3

Log Normal Probability Plot for Pu Concentrations (Pu/g) in Soils East of Indiana Street

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CHECKED BY Pbsmith 6/21/91
APPROVED BY A. Lange 6/21/91
DRAWING NUMBER RF 1015

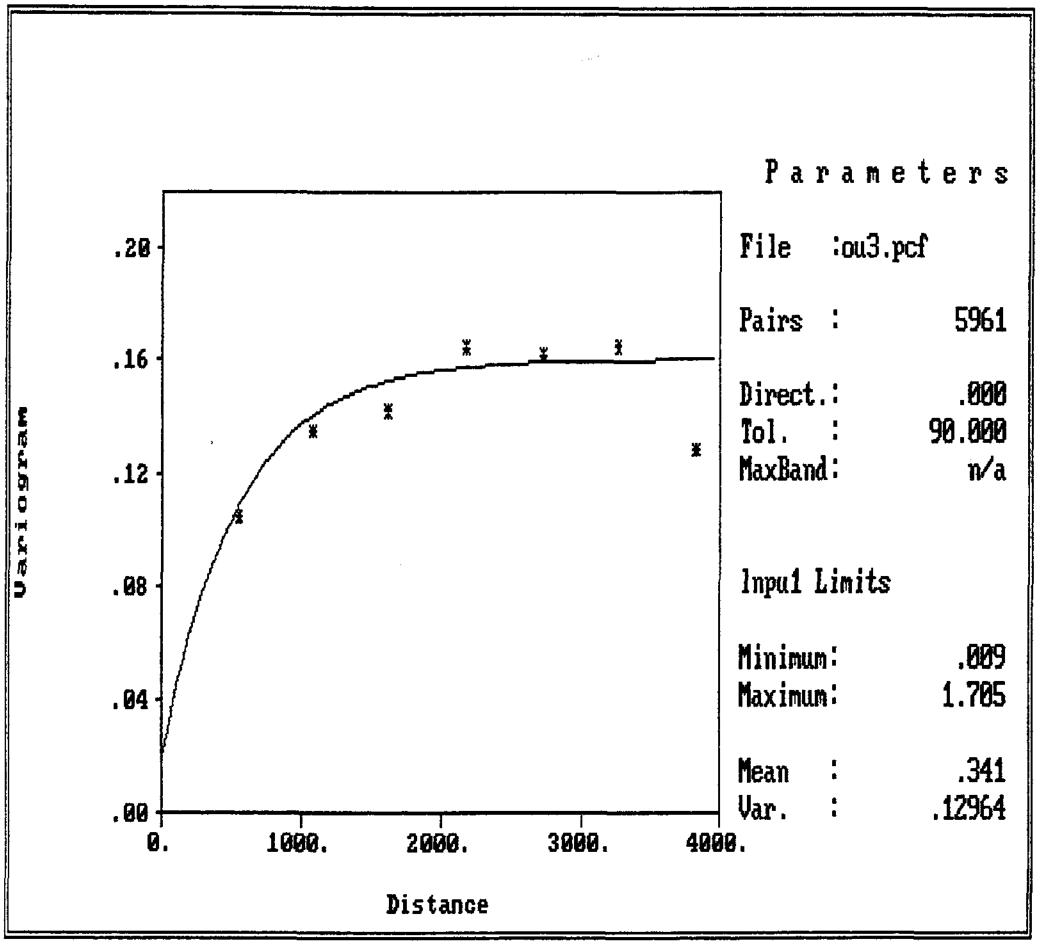

Figure D-4
Isotropic Variogram of Pu Concentrations (Pu/g) in Soils East of Indiana Street

The spatial variation of soil-plutonium east of the RFP did not change significantly with direction, which suggests that the semi-variogram is essentially isotropic.

Kriging estimates using the exponential model were computed for the soil-plutonium east of the RFP (Figure D-1). Plutonium concentrations higher than the recommended guideline by CDH (0.9 pCi/g) for residential areas were observed only near the eastern boundary of the RFP. The concentrations of plutonium decrease rapidly with distance and in all directions. It should be noted, that the plutonium concentrations depicted in Figure D-1 represents the conditions that existed during 1971 to 1978. Figure D-5 illustrates the kriging standard of error estimates which are low in the center of the sampled area, and which verify the goodness-of-fit of the kriging estimates in this location. Large standard of error estimates were observed in the east, south, and north to the RFP, which resulted from insufficient numbers of sample sites.

A maximum acceptable error of 0.41 pCi/g (see Figure D-6) was set, which seems reasonable following the CDH guideline for maximum allowable plutonium concentration in soils of residential areas. This value is equivalent to a kriging variance of 0.168, which provides an optimal sampling interval of 1750 m for the grid spacing for the proposed surficial soil sampling in OU 3. These calculations were based in part on the RFP soil sampling technique where five subsamples were collected from the corners and the center of two 1-m squares, spaced 1 m apart. The 10 subsamples were composited (5,000 cm^3) for radionuclides analyses. Surficial soil sampling for plutonium determination in the soils of OU 3 will follow the procedure recommended by the CDH. This soil sampling technique recommends the collection of 25 subsamples from a 10-acre area within a specified parcel of land to yield a single composite sample. The sample locations should be more or less evenly spaced within the area. The difference in block (area) size between the two techniques introduced some uncertainty in the above calculations. Hence, we recommend reducing the optimal sampling interval for 1,000 m between 10-ac plots to facilitate a more conservative grid spacing for the surficial soil sampling of OU 3. Because the semi-variogram was isotropic, the 1,000 m grid space will be used in all directions in the soils of OU 3 east of the RFP. Krey and Hardy (1970) published a plutonium-239 map that showed the location of the lowest plutonium concentration

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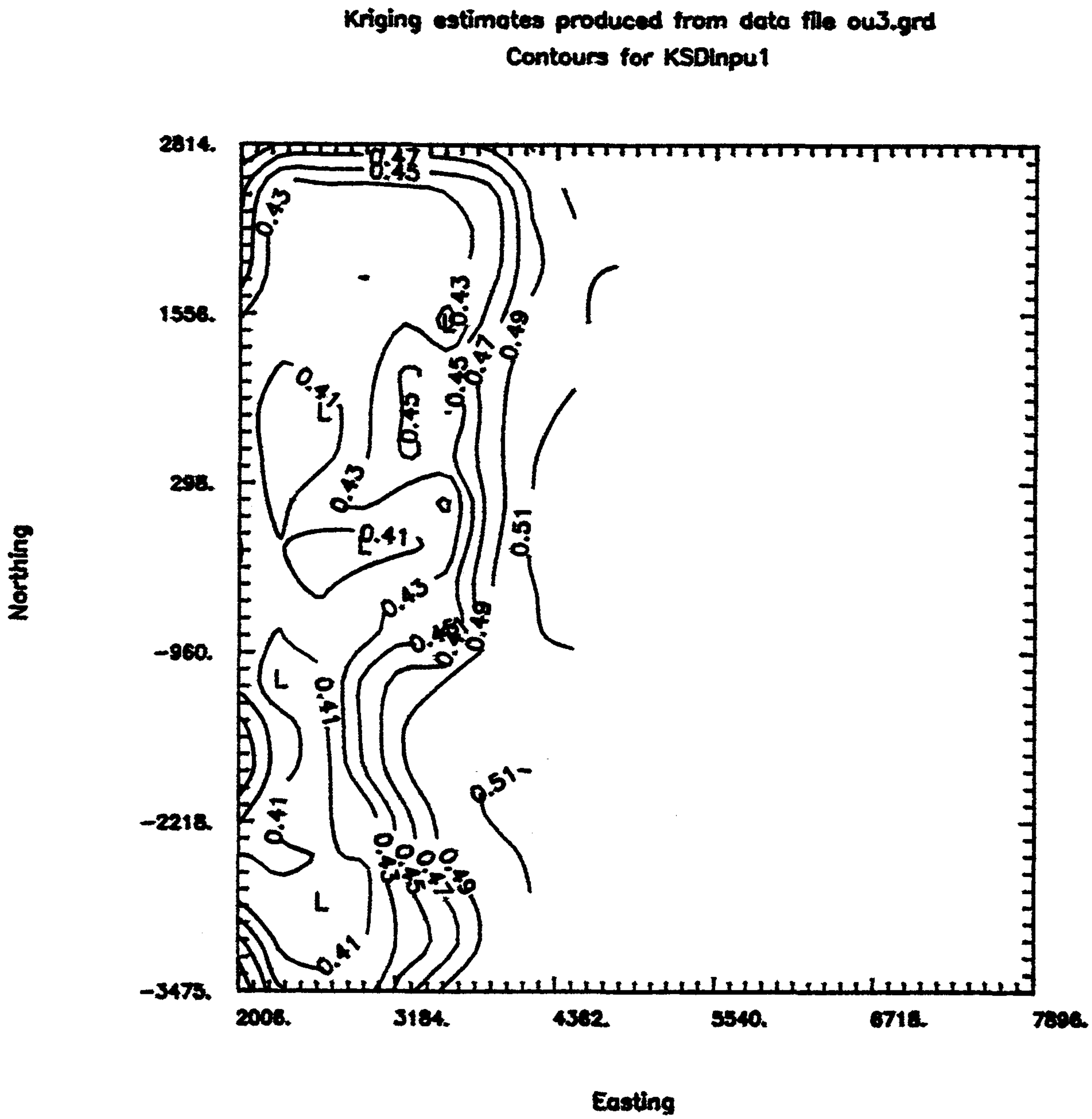
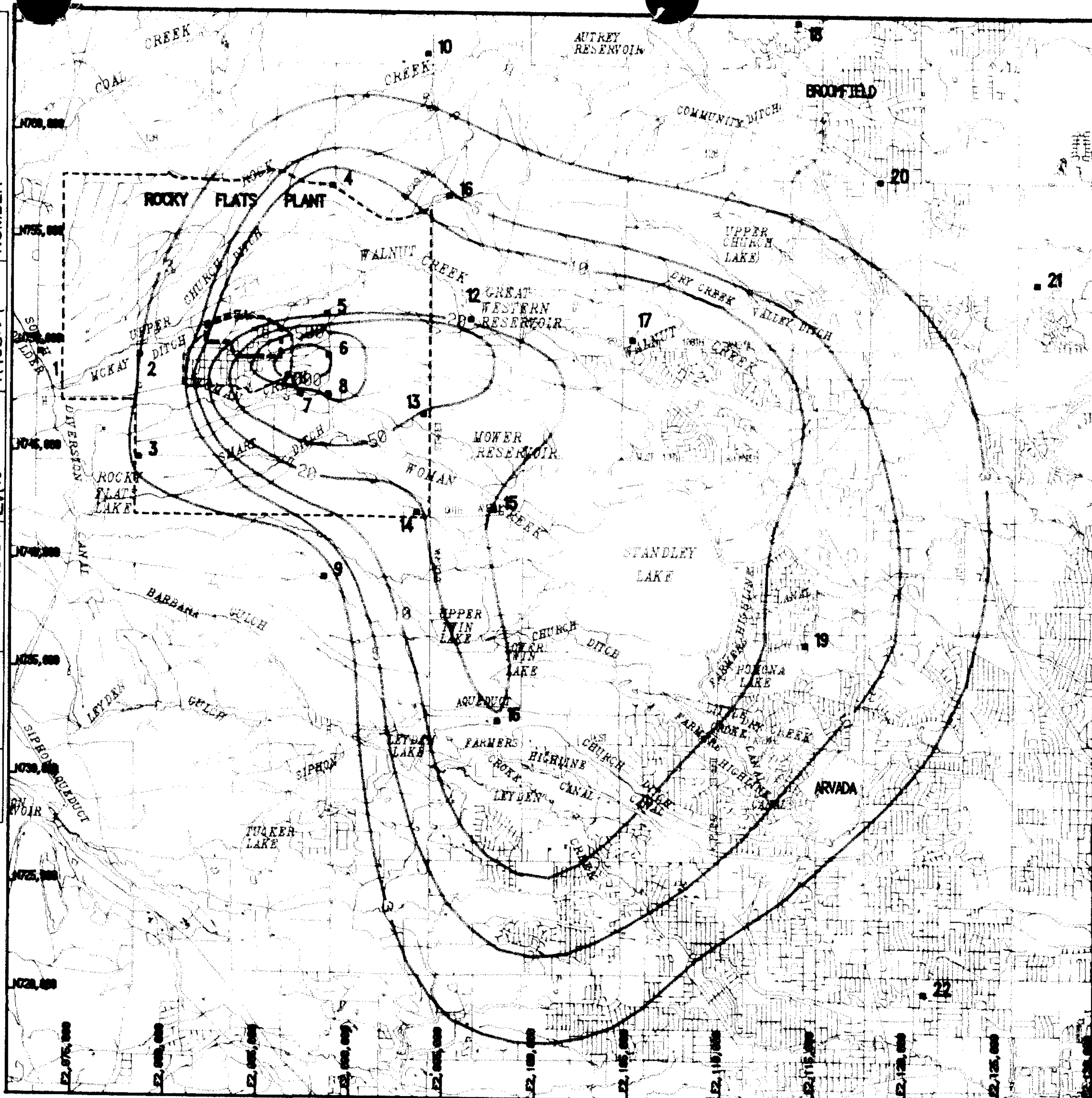


Figure D-5
Kriging Standard of Error Estimates for Pu in Soils East of Indiana Street

(approximately 0.3 pCi/g) around the RFP. The boundaries for the surficial soil sampling plan for OU 3 east of the RFP was determined on the basis of the smallest contour value in Krey and Hardy's map (Figure D-6).



MAP LEGEND

- RFP BOUNDARY AND PSZ
- CONTOUR VALUES IN mCi per km2
- NUMBERED SAMPLING SITES

0 feet 3400 6800

Figure D-6
Plutonium-239 Contours in the Vicinity of the Rocky Flats Plant Krey and Hardy (1970)

DRAWN BY	Douville 11/19/91	CHECKED BY	PBS 11/21/91	DRAWING NUMBER	RF1033
		APPROVED BY	KAW 11/22/91		

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APPENDIX E. PLUTONIUM 238 AND 239/240 TESTING OF THE SURFACE SOIL ON THE CONDA, SPICER, AND MCKAY GRAVEL LEASE PROPERTIES, ROCKY FLATS WEST BUFFER ZONE

WT Environmental
Consultants

13949 West Colfax Avenue, No. 140
Golden, Colorado 80401
303 233 2982 fax • 233 2991

Plutonium 238 and 239/240 Testing of the Surface Soil on the Conda, Spicer and McKay Gravel Lease Properties, Rocky Flats West Buffer Zone

PREPARED FOR:

Western Aggregates, Inc.
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1.0 EXECUTIVE SUMMARY

Surface soils on three gravel lease properties located within the Rocky Flats West Buffer Zone were sampled and analyzed for the plutonium isotopes 238 and 239/240 (see Figure 1 for property location). Colorado Department of Health (CDOH) operating procedures for plutonium sampling were strictly followed (Reference: Surface Soil Sample Collection, Version 1.0, July 10, 1989, CDOH). The laboratories used were sanctioned by EG&G (The Department of Energy's prime contractor for operating the Rocky Flats Nuclear Weapons Plant) with respect to QA/QC and laboratory analytical procedures. EG&G personnel inspected Western Technologies, Inc. (WT) field sampling protocol and approved the procedures.

No plutonium isotopes were detected above the CDOH action level. Plutonium concentrations in the surface soils on the subject properties are indicative of background levels resulting from atmospheric nuclear weapons testing.

The following conclusions are reached:

1. Plutonium concentrations in surface soils on the subject properties are below the CDOH action level (i.e. 2.0 disintegrations per minute per gram, which is equivalent to .9 pico Curies/gram) as put forth in "Rules and Regulations Pertaining to Radiation Control, RH 4.35.1".

2. Mining and related construction activities on the subject properties will not require any special construction techniques or mitigation because plutonium concentrations are below the CDOH action level.

3. Based on the data presented herein, no public health and safety hazard exists as a result of disturbing (e.g. mining, grading etc.) the soils on the subject properties.

2.0 INTRODUCTION

Western Aggregates, Inc. is contemplating sand and gravel mining on approximately 478 acres of land located on the Rocky Flats West Buffer Zone (Figure 1). The property is subdivided by the names of the owners of the gravel leases; Spicer, Conda, and McKay. Surface soils were sampled and analyzed for the plutonium isotopes 238 and 239/240 to insure public, worker, and customer safety.

The sampling program was in strict conformance with the Colorado Department of Health, Radiation Control Divisions' requirements as put forth in their document entitled "Surface Soil Sample Collection, Version 1.0, July 10, 1989". EG&G personnel approved the laboratories used, the sampling protocol and conducted field oversight of the sampling procedures. EG&G provided WT with a list of approved radionuclide laboratories from which Scientech, Inc. and Controls for Environmental Pollution, Inc. were selected. Two laboratories were selected at the recommendation of EG&G personnel for quality control purposes. A total of 54 soil samples were collected and analyzed (48 samples plus 6 split samples). The samples were collected from October 30 through November 1, 1990.

3.0 PLUTONIUM SAMPLING

The gravel lease properties were divided into fifty (50) sectors, each containing approximately 10 acres (see Figures 2 and 3 for sector locations). The 160 acre Conda lease was divided into 16 sectors, designated as WAI-C-1 through WAI-C-16. The 128 acre McKay property was divided into 12 sectors, designated as WAI-M-1 through WAI-M-12. The 190 acre Spicer property was divided into 22 sectors, designated as WAI-S-1 through WAI-S-22.

Prior to sampling, WT personnel clearly marked each of the sector corners with survey lath and fluorescent paint. Twenty five (25) plutonium sampling locations were selected in each of the sectors based on the following criteria:

- Sampling points were selected in relatively flat, open terrain. Special care was taken to avoid choosing sampling points near topographic features that would inhibit wind deposition of airborne plutonium from the Rocky Flats Plant.

- Surface soil conditions appeared to have remained undisturbed for several years. Soil was not sampled on two of the Conda sectors (WAI-C-2 and WAI-C-6), because these areas had been disturbed by recent mining activities.

- Sampling locations were evenly spaced within each sector, except in sector WAI-S-22, which contained deeply incised surface drainages. All sampling points were plotted in the field and are shown on Figures 2 and 3.

Each sampling sector covers approximately 10 acres, although some are odd shaped due to the property boundary. The sampling points shown on Figures 2 and 3 are approximately located as they were paced off in the field. Neither the sampling sectors nor the sampling points were surveyed. Soil samples were not collected from areas disturbed by on-going mining activities, roads, or steeply incised drainages.

3.1 Plutonium Sampling Procedures

Forty eight (48) composite soil samples and six (6) split samples were collected for laboratory analysis. Each of the samples were individually composited from soil collected at 25 sampling points located within each sector.

The individual soil samples were collected using a stainless steel sampling device from the top 1/4 (0.25) inch of soil, within a surface area 2 inches wide and 2 3/8 (2.375) inches long. WT personnel donned clean disposable latex gloves, and positioned the stainless steel template into the soil, so that the soil surface was even with the upper surface of the template. The stainless steel sampling spade was placed at the opposite end from the curved sample collection scoop, and carefully drawn forward towards the curved end. Special care was taken to assure that the entire volume (1/4 inch deep, 2 inches wide, and 2 3/8 inches long) was properly collected into the curved sample collection scoop. The curved end of the template was gently placed into a plastic sample collection bag, and the sample was slowly poured into the bag. Soil that adhered to the template was brushed into the container. The composite sample container was sealed, and the sample location was plotted on the map. WT personnel then proceeded to the next sample point.

Split samples were collected from the following sectors; WAI-C-1, WAI-C-14, WAI-M-6, WAI-M-8, WAI-S-16, and WAI-S-22. The split samples were composited from 25 sample locations in each of these sectors using the above procedures. At each sample point, the soil sample was divided evenly between two composite sample containers.

The stainless steel template and spade were thoroughly cleaned before sampling each sector, using non-phosphate soap and triple rinsed with deionized water. The 48 composite soil samples were labeled and sent to Scientech Laboratories in Carrollton, Texas, for analysis. As a quality assurance measure, the six split samples were sent to CEP Laboratories in Santa Fe, New Mexico.

4.0 PLUTONIUM SAMPLING RESULTS

The soil samples were analyzed for Plutonium 238 and 239/240 using alpha spectroscopy. Table 1 summarizes the laboratory analytical data by lease property. The Appendix contains the laboratory reports and chain of custody forms.

The lower limit of detection (LLD) for the analytical procedures used varied from .05 pCi/gm to .4 pCi/gm. This is an important point because in all cases the LLD was sufficient to determine compliance with the CDOH action level.

Plutonium 238 (Pu 238) values ranged from 0 pCi/gm (not detected above the detection limit) to .550 pCi/gm (in Conda Lease Sector C-14). Plutonium 239/240 (Pu 239/240) values ranged from 0 pCi/gm to .695 pCi/gm (in McKay Lease Sector M-9). In no case were CDOH action levels exceeded.

Split sample results are reasonably consistent although C-14A and C-14B varied from 0 pCi/gm to 0.550 pCi/ gm respectively. Conversations with Ms. Karen Schoendaller of EG&G revealed this is not uncommon, due to the non-homogenous nature of airborne deposition of plutonium. These results are not interpreted as laboratory problems.

5.0 CONCLUSIONS

All samples were collected using appropriate protocol and were analyzed by qualified laboratories. The LLD was sufficient to determine compliance with CDOH action levels. The results are consistent with previous, limited sampling performed by the Department of Energy in the same general vicinity. The results presented herein are believed to be an accurate representation of plutonium concentrations in surface soils on the subject property. Plutonium concentrations are known to decrease dramatically with depth.

Based on the data presented in this report the following conclusions are reached.

1. Plutonium concentrations in surface soils on the subject properties are below the CDOH action level (i.e. 2.0 disintegrations per minute per gram, which is equivalent to .9 pico Curies/gram) as put forth in "Rules and Regulations Pertaining to Radiation Control, RH 4.35.1".

2. Mining and related construction activities on the subject properties will not require any special construction techniques or mitigation because plutonium concentrations are below the CDOH action level.

3. Based on the data presented herein, no public health and safety hazard exists as a result of disturbing (e.g. mining, grading etc.) the soils on the subject properties.

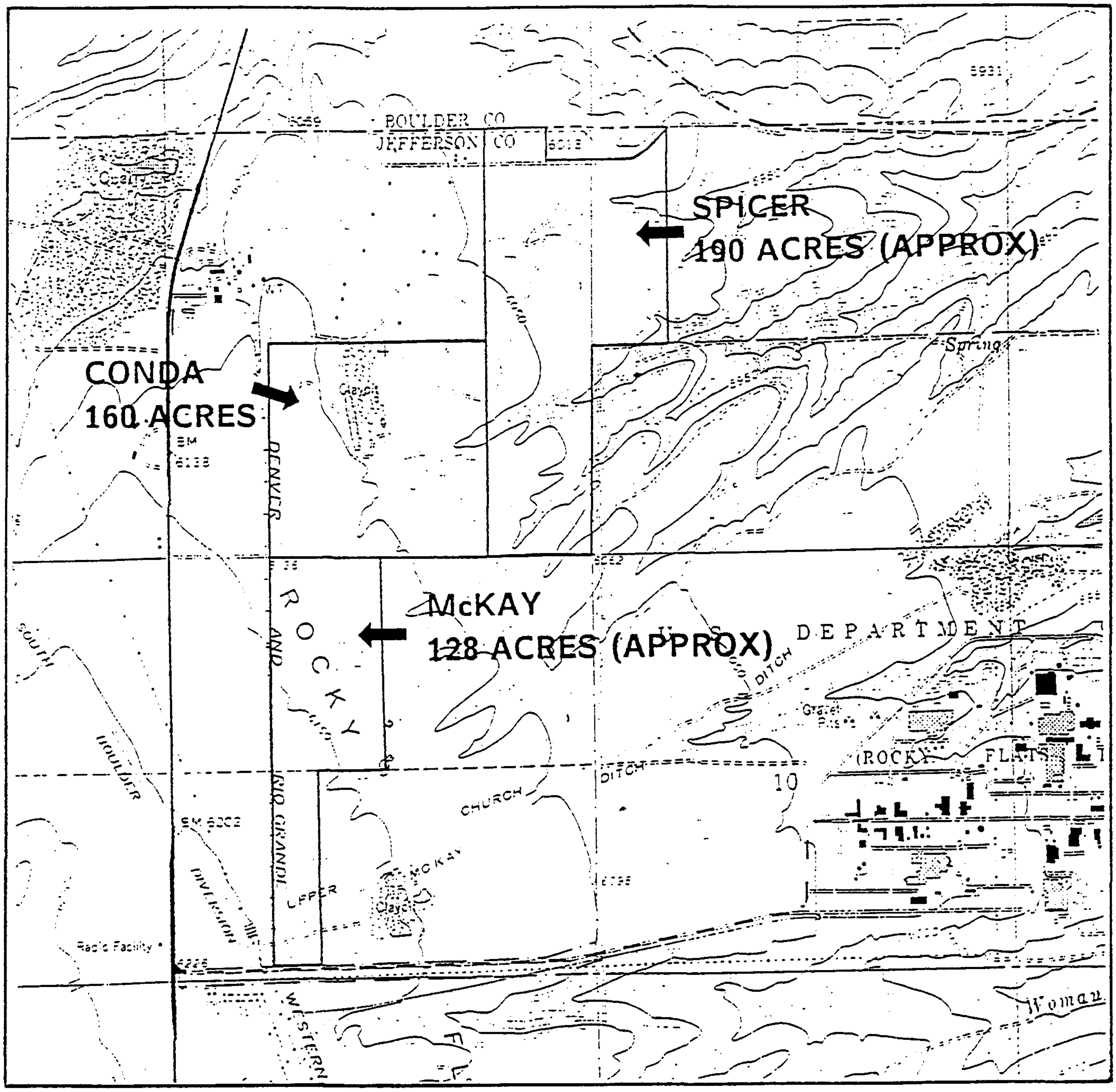
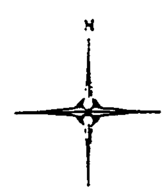
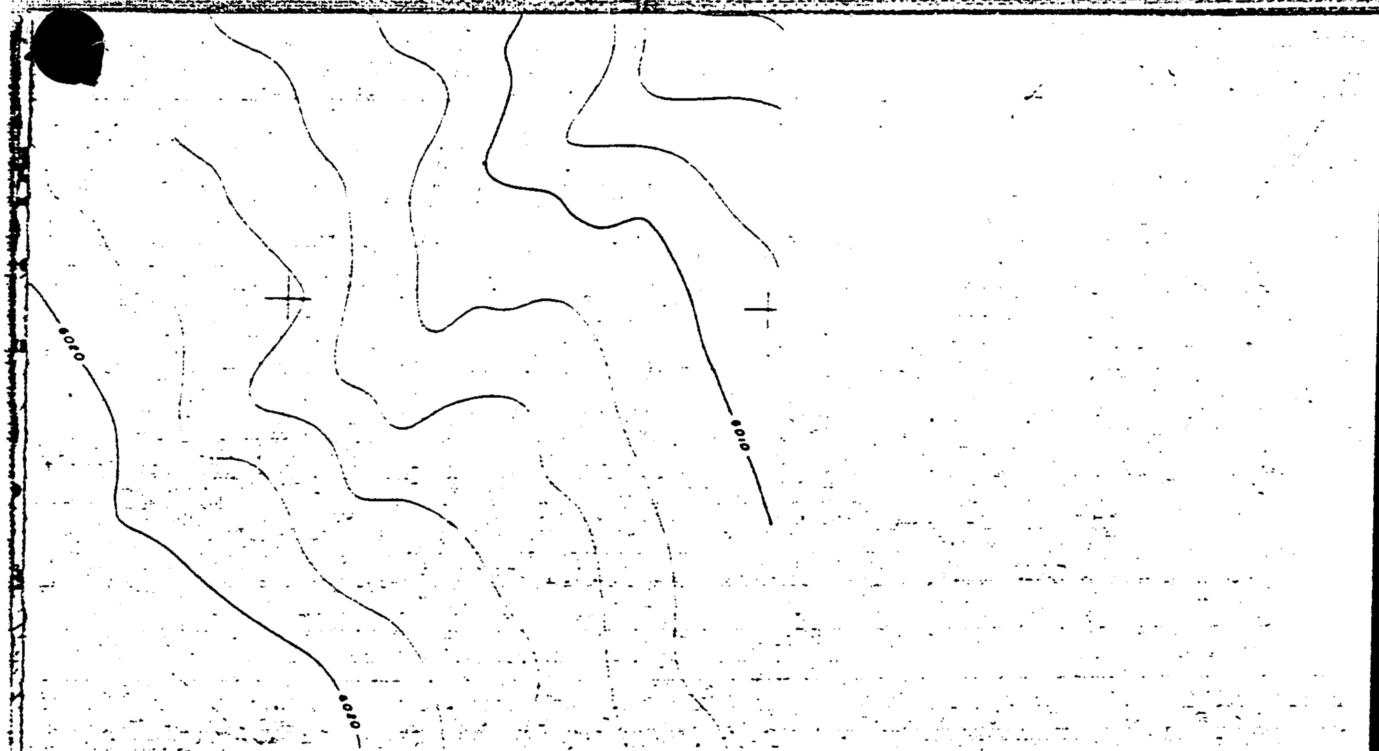


FIGURE 1: INDEX MAP OF GRAVEL LEASE PROPERTIES

Scale 1" = 2000'
Contour interval = 10 ft.



Project No. 769-OK-077



WESTERN TECHNOLOGIES INC.

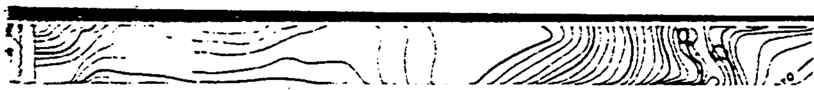
PLUTONIUM SAMPLING LOCATIONS
CONDA AND SPICER LEASES

PREPARED FOR

WESTERN AGGREGATES INC.

SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:
1" = 200'	12-6-90	769-OK-077	2

Blueprint map included in report.



WESTERN
TECHNOLOGIES
INC.

PLUTONIUM SAMPLING LOCATIONS

Mc KAY LEASE

PREPARED FOR

WESTERN AGGREGATES INC.

SCALE	DATE	PROJECT NO.	FIGURE NO.
1" = 300'	12-5-90	769-OK-077	3

Blueprint map included in report.

APPENDIX

LABORATORY ANALYTICAL DATA AND CHAIN OF CUSTODY FORMS

TABLE 1: Summary of Plutonium Test Results

SAMPLING LOCATIONS		ANALYTES (1)	
CONDA LEASE		Pu 238	Pu 239/240
SECTOR	C-1A (2)	0	0
	C-1B	<0.05	<0.05
	C-2	(3)	(3)
	C-3	0	0.0286
	C-4	0	0.0974
	C-5	0.0577	0.0019
	C-6	(3)	(3)
	C-7	0.147	0.0194
	C-8	0.204	0.0444
	C-9	0.0637	0.0021
	C-10	0	0
	C-11	0	0.151
	C-12	0.0883	0.221
	C-13	0.0579	0.232
	C-14A	0	0.141
	C-14B	0.550	0.260
	C-15	0.00814	0.141
	C-16	0.124	0.153
MCKAY LEASE		Pu 238	Pu 239/240
SECTOR	M-1	0.193	0.0551
	M-2	0.211	0.079
	M-3	0	0.424
	M-4	0	0.106
	M-5	0	0.193
	M-6A	0.0835	0.0501
	M-6B	0.270	0.070
	M-7	0	0.187
	M-8A	0	0.151
	M-8B	<0.05	<0.05
	M-9	0.0347	0.695
	M-10	0.0106	0.106
	M-11	0	0.0167
	M-12	0.285	0.327

TABLE 1 (CONTINUED)

SPICER LEASE		Pu 238	Pu 239/240
SECTOR	S-1	0.0103	0.175
	S-2	0	0
	S-3	0.0879	0.055
	S-4	0.0366	0.175
	S-5	0	0
	S-6	0	0.0602
	S-7	0	0.0498
	S-8	0	0.0398
	S-9	0.0159	0.143
	S-10	0	0.0167
	S-11	0	0
	S-12	0	0.0635
	S-13	0	0.0657
	S-14	0	0.0965
	S-15	0	0
	S-16A	0	0.0399
	S-16B	<0.05	<0.05
	S-17	0	0.0614
	S-18	0	0.0712
	S-19	0	0.0884
	S-20	0	0.152
	S-21	0	0.0334
	S-22A	0	0.0318
	S-22B	<0.05	0.290

NOTES:

(1) All units are in pico curies/gram (pCi/gm).

(2) Samples labelled A and B are split samples.
Samples with the A designation were analyzed by Scientech, Inc.
Samples with the B designation were analyzed by C.E.P, Inc.
All other samples were analyzed by Scientech, Inc.

(3) No samples collected in these sectors because soil was disturbed by recent minimg activities.

The Colorado Department of Health, Radiation Control Division, has established an action level for plutonium contamination of 2.0 disintegrations per minute per gram (dpm/gm). This is equivalent to 0.9 pCi/gm. None of the 54 samples analyzed exceeded this standard.

received
1-3-91

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REPORT OF ANALYSIS

ANL JOB# 90-0843

12/28/90

WESTERN TECHNOLOGIES INC. 10275

48 SOIL SAMPLES, DATE RECEIVED 11/15/90

SAMPLE I. D.	ANALYSIS	CONCENTRATION	ERROR EST.	UNITS	LLD	UNITS
WAI-C-PU-	PU-238	0.00 E + 0	8.78 E - 2	pCi/g	2 E - 7	uCi/g
1A	PU-239	0.00 E + 0	8.01 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12932	PU-240	*				
WAI-C-PU-	PU-238	0.00 E + 0	8.57 E - 2	pCi/g	2 E - 7	uCi/g
3	PU-239	2.86 E - 2	8.97 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12933	PU-240	*				
WAI-C-PU-	PU-238	0.00 E + 0	7.79 E - 2	pCi/g	2 E - 7	uCi/g
4	PU-239	9.74 E - 2	9.00 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12934	PU-240	*				
WAI-C-PU-	PU-238	5.77 E - 2	2.09 E - 1	pCi/g	3 E - 7	uCi/g
5	PU-239	1.90 E - 3	1.45 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12935	PU-240	*				
WAI-C-PU-	PU-238	1.47 E - 1	1.64 E - 1	pCi/g	2 E - 7	uCi/g
7	PU-239	1.94 E - 2	1.03 E - 1	pCi/g	1 E - 7	uCi/g
A.N.L. 12936	PU-240	*				
WAI-C-PU-	PU-238	2.04 E - 1	1.48 E - 1	pCi/g	1 E - 7	uCi/g
8	PU-239	4.44 E - 2	9.16 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12937	PU-240	*				
WAI-C-PU-	PU-238	6.37 E - 2	2.30 E - 1	pCi/g	3 E - 7	uCi/g
9	PU-239	2.10 E - 3	1.60 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12938	PU-240	*				
WAI-C-PU-	PU-238	0.00 E - 0	1.46 E - 1	pCi/g	3 E - 7	uCi/g
10	PU-239	0.00 E - 0	1.14 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12939	PU-240	*				

THESE ANALYSES WERE PERFORMED USING
NBS TRACEABLE PROCEDURES AND STANDARDS.
* ANALYSIS INCOMPLETE OR RE-TESTING

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SAMPLE I. D.	ANALYSIS	CONCENTRATION	ERROR EST.	UNITS	LLD	UNITS
WAI-C-PU-	PU-238	0.00 E + 0	1.04 E - 1	pCi/g	2 E - 7	uCi/g
11	PU-239	1.51 E - 1	1.06 E - 1	pCi/g	1 E - 7	uCi/g
A.N.L. 12940	PU-240	*				
WAI-C-PU-	PU-238	8.83 E - 2	1.87 E - 1	pCi/g	3 E - 7	uCi/g
12	PU-239	2.21 E - 1	1.71 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12941	PU-240	*				
WAI-C-PU-	PU-238	5.79 E - 2	1.45 E - 1	pCi/g	2 E - 7	uCi/g
13	PU-239	2.32 E - 1	1.44 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12942	PU-240	*				
WAI-C-PU-	PU-238	0.00 E + 0	2.33 E - 2	pCi/g	4 E - 8	uCi/g
14A	PU-239	1.41 E - 1	3.88 E - 2	pCi/g	3 E - 8	uCi/g
A.N.L. 12943	PU-240	*				
WAI-C-PU-	PU-238	8.14 E - 3	3.32 E - 2	pCi/g	5 E - 8	uCi/g
15	PU-239	1.41 E - 1	4.51 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12944	PU-240	*				
WAI-C-PU-	PU-238	1.24 E - 1	5.10 E - 2	pCi/g	6 E - 8	uCi/g
16	PU-239	1.53 E - 1	4.90 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12945	PU-240	*				
WAI-M-PU-	PU-238	1.93 E - 1	1.91 E - 1	pCi/g	3 E - 7	uCi/g
1	PU-239	5.51 E - 2	1.32 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12946	PU-240	*				
WAI-M-PU-	PU-238	2.11 E - 1	1.86 E - 1	pCi/g	3 E - 7	uCi/g
2	PU-239	7.90 E - 2	1.32 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12947	PU-240	*				

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WAI-M-PU-	PU-238	0.00 E + 0	2.20 E - 1	pCi/g	4 E - 7	uCi/g
3	PU-239	4.24 E - 1	2.63 E - 1	pCi/g	3 E - 7	uCi/g
A.N.L. 12948	PU-240	*				
WAI-M-PU-	PU-238	0.00 E - 0	4.15 E - 2	pCi/g	8 E - 8	uCi/g
4	PU-239	1.06 E - 1	5.57 E - 2	pCi/g	6 E - 8	uCi/g
A.N.L. 12949	PU-240	*				
WAI-M-PU-	PU-238	0.00 E + 0	5.40 E - 2	pCi/g	9 E - 8	uCi/g
5	PU-239	1.93 E - 1	7.09 E - 2	pCi/g	7 E - 8	uCi/g
A.N.L. 12950	PU-240	*				
WAI-M-PU-	PU-238	8.35 E - 2	1.43 E - 1	pCi/g	2 E - 7	uCi/g
6A	PU-239	5.01 E - 2	1.27 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12951	PU-240	*				
WAI-M-PU-	PU-238	0.00 E - 0	1.41 E - 1	pCi/g	3 E - 7	uCi/g
7	PU-239	1.37 E - 1	1.53 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12952	PU-240	*				
WAI-M-PU-	PU-238	0.00 E - 0	1.81 E - 2	pCi/g	4 E - 8	uCi/g
8A	PU-239	1.51 E - 1	5.74 E - 2	pCi/g	3 E - 8	uCi/g
A.N.L. 12953	PU-240	*				
WAI-M-PU-	PU-238	3.47 E - 2	2.10 E - 1	pCi/g	3 E - 7	uCi/g
9	PU-239	6.95 E - 1	2.64 E - 1	pCi/g	3 E - 7	uCi/g
A.N.L. 12954	PU-240	*				
WAI-M-PU-	PU-238	1.06 E - 2	4.34 E - 2	pCi/g	5 E - 8	uCi/g
10	PU-239	1.06 E - 1	6.09 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12955	PU-240	*				

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WAI-M-PU-	PU-238	0.00 E + 0	3.14 E - 2	pCi/g	5 E - 8	uCi/g
11	PU-239	1.67 E - 2	3.68 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12956	PU-240	*				
WAI-M-PU-	PU-238	2.85 E - 1	2.09 E - 1	pCi/g	3 E - 7	uCi/g
12	PU-239	3.27 E - 1	1.83 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12957	PU-240	*				
WAI-S-PU-	PU-238	1.03 E - 2	3.19 E - 2	pCi/g	5 E - 8	uCi/g
1	PU-239	1.75 E - 1	4.74 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12958	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	1.44 E - 1	pCi/g	3 E - 7	uCi/g
2	PU-239	0.00 E - 0	8.30 E - 2	pCi/g	2 E - 7	uCi/g
A.N.L. 12959	PU-240	*				
WAI-S-PU-	PU-238	8.79 E - 2	5.56 E - 2	pCi/g	7 E - 8	uCi/g
3	PU-239	5.50 E - 2	4.25 E - 2	pCi/g	5 E - 8	uCi/g
A.N.L. 12960	PU-240	*				
WAI-S-PU-	PU-238	3.66 E - 2	3.63 E - 2	pCi/g	5 E - 8	uCi/g
4	PU-239	1.75 E - 1	4.78 E - 2	pCi/g	4 E - 8	uCi/g
A.N.L. 12961	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	8.51 E - 2	pCi/g	2 E - 7	uCi/g
5	PU-239	0.00 E - 0	7.02 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12962	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	8.08 E - 2	pCi/g	2 E - 7	uCi/g
6	PU-239	6.02 E - 2	8.76 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12963	PU-240	*				

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WAI-S-PU-	PU-238	0.00 E + 0	6.39 E - 2	pCi/g	1 E - 7	uCi/g
7	PU-239	4.98 E - 2	7.25 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12964	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	8.11 E - 2	pCi/g	2 E - 7	uCi/g
8	PU-239	3.98 E - 2	7.81 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12965	PU-240	*				
WAI-S-PU-	PU-238	1.59 E - 2	9.63 E - 2	pCi/g	2 E - 7	uCi/g
9	PU-239	1.43 E - 1	9.63 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12966.	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	7.85 E - 2	pCi/g	2 E - 7	uCi/g
10	PU-239	1.67 E - 2	7.68 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12967	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	6.67 E - 2	pCi/g	1 E - 7	uCi/g
11	PU-239	0.00 E - 0	7.63 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12968	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.26 E - 1	pCi/g	2 E - 7	uCi/g
12	PU-239	6.35 E - 2	1.47 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12969	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.22 E - 1	pCi/g	2 E - 7	uCi/g
13	PU-239	6.57 E - 2	1.17 E - 1	pCi/g	1 E - 7	uCi/g
A.N.L. 12970	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.31 E - 1	pCi/g	2 E - 7	uCi/g
14	PU-239	9.65 E - 2	1.41 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12971	PU-240	*				

THESE ANALYSES WERE PERFORMED USING
NBS TRACEABLE PROCEDURES AND STANDARDS.
* ANALYSIS INCOMPLETE OR RE-TESTING

M L Buvinghausen

M. L. Buvinghausen
Deputy Director, Laboratory

SCIENTECH INC.
ENGINEERING & MANAGEMENT SERVICES
2105 LUNA ROAD, #390, CARROLLTON, TX 75006
(214) 247-1714 FAX (214) 247-0268

REPORT OF ANALYSIS

ANL JOB# 90-0843

12/28/90

WESTERN TECHNOLOGIES INC. 10275

48 SOIL SAMPLES, DATE RECEIVED 11/15/90

SAMPLE I. D.	ANALYSIS	CONCENTRATION	ERROR EST.	UNITS	LLD	UNITS
WAI-S-PU-	PU-238	0.00 E + 0	1.29 E - 1	pCi/g	2 E - 7	uCi/g
15	PU-239	0.00 E + 0	1.28 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12972	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	7.63 E - 2	pCi/g	2 E - 7	uCi/g
16A	PU-239	3.99 E - 2	7.68 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12973	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	1.45 E - 1	pCi/g	3 E - 7	uCi/g
17	PU-239	6.14 E - 2	1.46 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12974	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.15 E - 1	pCi/g	2 E - 7	uCi/g
18	PU-239	7.12 E - 2	1.16 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12975	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	1.40 E - 1	pCi/g	2 E - 7	uCi/g
19	PU-239	8.84 E - 2	1.26 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12976	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.30 E - 1	pCi/g	3 E - 7	uCi/g
20	PU-239	1.52 E - 1	1.59 E - 1	pCi/g	2 E - 7	uCi/g
A.N.L. 12977	PU-240	*				
WAI-S-PU-	PU-238	0.00 E + 0	7.50 E - 2	pCi/g	2 E - 7	uCi/g
21	PU-239	3.34 E - 2	8.02 E - 2	pCi/g	1 E - 7	uCi/g
A.N.L. 12978	PU-240	*				
WAI-S-PU-	PU-238	0.00 E - 0	1.04 E - 1	pCi/g	2 E - 7	uCi/g
22A	PU-239	3.18 E - 2	9.96 E - 2	pCi/g	2 E - 7	uCi/g
A.N.L. 12979	PU-240	*				

THESE ANALYSES WERE PERFORMED USING
NBS TRACEABLE PROCEDURES AND STANDARDS.
* ANALYSIS INCOMPLETE OR RE-TESTING

M. L. Buvinghausen
M. L. Buvinghausen
Deputy Director, Laboratory

CHAIN OF CUSTODY RECORD

JOB NO. 769-OK-077

PROJECT NAME WAI- CONDA/McKAY/SPICER

SAMPLERS: (SIGNATURE) David P. Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	CRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	~~SPLIT-SPOON~~	CDH Samples		Pu 238,239/240	REMARKS (PHYSICAL APPEARANCE, etc.)	LABORATORY IDENTIFICATION
WAI-C-Pu-1A	10/30		X		CONDA - SECTOR 1	1					X		X	SOIL	
WAI-C-Pu-3	10/30		X		CONDA - SECTOR 3	1					X		X		
WAI-C-Pu-4	10/30		X		CONDA - SECTOR 4	1					X		X		
WAI-C-Pu-5	10/31		X		CONDA - SECTOR 5	1					X		X		
WAI-C-Pu-7	10/30		X		CONDA - SECTOR 7	1					X		X		
WAI-C-Pu-8	10/30		X		CONDA - SECTOR 8	1					X		X		
WAI-C-Pu-9	10/31		X		CONDA - SECTOR 9	1					X		X		
WAI-C-Pu-10	10/31		X		CONDA - SECTOR 10	1					X		X		
WAI-C-Pu-11	11/1		X		CONDA - SECTOR 11	1					X		X		
WAI-C-Pu-12	10/31		X		CONDA - SECTOR 12	1					X		X		
WAI-C-Pu-13	10/31		X		CONDA - SECTOR 13	1					X		X		
WAI-C-Pu-14A	10/31		X		CONDA - SECTOR 14	1					X		X		
WAI-C-Pu-15	10/31		X		CONDA - SECTOR 15	1					X		X		
WAI-C-Pu-16	10/31		X		CONDA - SECTOR 16	1					X		X		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P. Schwieger	11/13						

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME	REMARKS
						• 0.2 piCu/g LLD • 30-45 DAY TURN AROUND

WESTERN TECHNOLOGIES INC.
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~~Phoenix, Arizona—85036~~
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13949 W. COLFAX
SUITE 140
GOLDEN, CO 80401
303-233-2991

White-Testing Laboratory; Yellow-Field Sampler; Pink-Department Job File

CHAIN OF CUSTODY RECORD

JOB NO.	PROJECT NAME
769-OK-077	WAI - CONDA /McKAY /SPICER

SAMPLERS: (SIGNATURE) David F. Schwiezer

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	CRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	SPLIT-SPOON	CDH Sampler		Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE, etc.)	LABORATORY IDENTIFICATION
WAI-M-Pu-1	11/1		X		McKay-Sector 1	1					X		X	SOIL	
WAI-M-Pu-2	↓		X		McKay-Sector 2	1					X		X	↓	
WAI-M-Pu-3.			X		McKay-Sector 3	1					X		X		
WAI-M-Pu-4.			X		McKay-Sector 4	1					X		X		
WAI-M-Pu-5			X		McKay-Sector 5	1					X		X		
WAI-M-Pu-6A			X		McKay-Sector 6	1					X		X		
WAI-M-Pu-7.			X		McKay-Sector 7	1					X		X		
WAI-M-Pu-8A			X		McKay-Sector 8	1					X		X		
WAI-M-Pu-9			X		McKay-Sector 9	1					X		X		
WAI-M-Pu-10			X		McKay-Sector 10	1					X		X		
WAI-M-Pu-11			X		McKay-Sector 11	1					X		X		
WAI-M-Pu-12	↓		X		McKay-Sector 12	1					X		X	↓	

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David F. Schwiezer	11/13						
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SUITE ~~140~~
GOLDEN 80401
303-23 2991

White-Testing Laboratory; Yellow-Field Sampler; Pink-Department Job Fi

CHAIN OF CUSTODY RECORD

JOB NO.	PROJECT NAME
769-OK-077	WAI - Conda / McKay / Spicer
SAMPLERS: (SIGNATURE)	David P. Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	GRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	SPLIT-SPOON	CDH Sampler		Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE, etc.)	LABORATORY IDENTIFICATION
WAI-S-Pu-1	10/30		X		Spicer - Sector 1	1					X		X	Soil	
WAI-S-Pu-2	10/30		X		Spicer - Sector 2	1					X		X		
WAI-S-Pu-3	10/30		X		Spicer - Sector 3	1					X		X		
WAI-S-Pu-4	10/30		X		Spicer - Sector 4	1					X		X		
WAI-S-Pu-5	10/30		X		Spicer - Sector 5	1					X		X		
WAI-S-Pu-6	10/31		X		Spicer - Sector 6	1					X		X		
WAI-S-Pu-7	10/30		X		Spicer - Sector 7	1					X		X		
WAI-S-Pu-8	10/30		X		Spicer - Sector 8	1					X		X		
WAI-S-Pu-9	10/31		X		Spicer - Sector 9	1					X		X		
WAI-S-Pu-10	10/31		X		Spicer - Sector 10	1					X		X		
WAI-S-Pu-11	10/30		X		Spicer - Sector 11	1					X		X		
WAI-S-Pu-12	10/30		X		Spicer - Sector 12	1					X		X		
WAI-S-Pu-13	10/31		X		Spicer - Sector 13	1					X		X		
WAI-S-Pu-14	10/31		X		Spicer - Sector 14	1					X		X		
WAI-S-Pu-15	10/31		X		Spicer - Sector 15	1					X		X		
WAI-S-Pu-16A	10/31		X		Spicer - Sector 16	1					X		X		

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David P. Schwieger	11/13						
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White-Testing Laboratory; Yellow-Field Sampler; Pink-Department Job File

CHAIN OF CUSTODY RECORD

JOB NO. 769-OK-077

PROJECT NAME WAI- CONDA/McKAY/SPICER

SAMPLERS: (SIGNATURE) David P. Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	GRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	~~SOIL AUGAR~~	SPLIT-SPOON	CDH Sampler	Pu 238,239/240	REMARKS (PHYSICAL APPEARANCE, etc.)	LABORATORY IDENTIFICATION
WAI-S-Pu-17	10/31		X		SPICER - SECTOR 17	1					X	X	SOIL	
WAI-S-Pu-18	↓		X		SPICER - SECTOR 18	1					X	X	↓	
WAI-S-Pu-19	↓		X		SPICER - SECTOR 19	1					X	X	↓	
WAI-S-Pu-20	↓		X		SPICER - SECTOR 20	1					X	X	↓	
WAI-S-Pu-21	↓		X		SPICER - SECTOR 21	1					X	X	↓	
WAI-S-Pu-22A	↓		X		SPICER - SECTOR 22	1					X	X	↓	

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P. Schwieger		11/13					

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RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME	REMARKS
						• 0.2 piCu/g LLD • 30-45 DAY TURN AROUND

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13949 W. COLFAX
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GOLDE[redacted] 80401
[redacted] -7991

White-Testing Laboratory; Yellow-Field Sampler; Pink-Department Jo[redacted]

Controls for Environmental Pollution, Inc.
OUT OF STATE 800/545-2188 • FAX - 505-982-92

Controls for Environmental
Pollution, Inc.
P.O. Box 5351
Santa Fe, NM 87502
Attn: James J. Mueller
Phone: (505) 982-9841

Western Technologies, Inc
13949 West Colfax Avenue #140
Golden, CO 80401

Attn: David P. Schwieger
Invoice Number:

Order #: 90-11-314
Date: 12/18/90 10:34
Work ID: Environmental
Date Received: 11/14/90
Date Completed: 12/03/90

SAMPLE IDENTIFICATION

Sample Number	Sample Description	Sample Number	Sample Description
01	WAI-C-PU-1B CONDA-SEC 1	02	WAI-C-PU-14B Conda-Sec 14
03	WAI-M-PU-6B McKay-Sec 6	04	WAI-M-PU-8B McKay-Sector 8
05	WAI-S-PU-16B Spicer-Sec 16	06	WAI-S-PU-22B Spicer-Sec 22

Remainder of sample(s) for routine analysis will be disposed of three weeks from final report date. Sample(s) for bacteria analysis only, will be disposed of immediately after analysis. This is not applicable if other arrangements have been made.

Certified By

received
12-24-90

Controls for Environmental Pollution, Inc.
OUT OF STATE 800/545-2188 • FAX - 505-982-9289

Order # 90-11-314 Controls for Environmental
12/18/90 10:34

TEST RESULTS BY SAMPLE

Sample: 01A WAI-C-PU-1B CONDA-SEC 1 Collected: 10/30/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	<0.05	0.05	pCi/gram		

Sample: 02A WAI-C-PU-14B Conda-Sec 14 Collected: 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	0.55±0.12	0.05	pCi/gram		
Plutonium-239/240	0.26±0.08	0.05	pCi/gram		

Sample: 03A WAI-M-PU-6B McKay-Sec 6 Collected: 11/01/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	0.27±0.06	0.05	pCi/gram		
Plutonium-239/240	0.07±0.05	0.05	pCi/gram		

Sample: 04A WAI-M-PU-8B McKay-Sector 8 Collected: 11/01/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	<0.05	0.05	pCi/gram		

Controls for Environmental [illegible]tion, Inc.
OUT OF STATE 800/545-2188 • FAX - 505-982-92

Sample: 05A WAI-S-PU-16B Spicer-Sec 16 Collected: 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	<0.05	0.05	pCi/gram		

Sample: 06A WAI-S-PU-22B Spicer-Sec 22 Collected: 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	0.29±0.11	0.05	pCi/gram		

RESPONSE TO COMMENTS

RFI/RI WORK PLAN
FOR OU 3

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

FEBRUARY 28, 1992

DEN/FLATS18/051.51

RESPONSE TO COMMENTS

RFI/RI WORK PLAN
FOR OU 3

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

FEBRUARY 28, 1992

DEN/FLATS18/051.51

Responses to Comments on the December 6, 1991 Final Draft OU 3 RFI/RI Work Plan

Introduction

DOE and EG&G appreciate the opportunity to respond to the comments received on the Final OU 3 RFI/RI Work Plan dated December 1991. Comment responses have been prepared for comments received from EPA and CDH. The comments are presented followed by DOE's response. The Final Work Plan has been revised to incorporate many of the comments received.

EPA Comments and Comment Responses

Comment 1. Section 5.1.4, Specify RFI/RI Objectives and Data Needs. The objectives stated in this section are deficient. They indicate an intention to inappropriately limit the characterization of the nature and extent of contamination in OU 3. Section 300.430 (d) of the NCP states, "The purpose of the remedial investigation is to collect data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives." One of the remedial alternatives may be no action. DOE's insistence on limiting the objectives of the OU 3 remedial investigation will ensure that insufficient data will be available to develop and evaluate the no action alternative as well as all possible remedial alternatives. The objectives must be modified to broaden the scope of the remedial investigation to characterize the nature and extent of all contamination either resulting from Rocky Flats Plant releases or co-mingled with Rocky Flats Plant releases.

Response 1. The objectives of the RFI/RI presented in this section have been revised. The second bullet has been revised to "Characterize the nature and extent of contamination in each IHSS in each media that is a potential pathway." The third bullet has been eliminated to avoid redundancy.

Comment 2. The work plan fails to demonstrate coordination between the OU 3 remedial investigation activities and the Option B project activities. DOE makes reference to Option B in two paragraphs of the work plan. DOE fails to include relevant Option B project activities in the OU 3 project schedule. As the work plan is written, there is no assurance that the nature and extent of contamination within the Option B project area will be determined before construction activities begin. We state again that it is DOE's responsibility to ensure that any construction activity within OU 3 does not exacerbate the threat to human health or the environment by spreading the existing contamination, does not otherwise interfere with ongoing

Comprehensive Environmental Response, Compensation, and Liability Act response activities, and does not result in increased response cost. The OU 3 work plan fails to demonstrate that this responsibility will be met.

Response 2. The discussion regarding Option B in Section 1.3.9 of the work plan has been expanded to discuss coordination and schedule issues associated with Option B.

Comment 3. Section 6, page 28, paragraph 6.3.1.2 Sediment Reservoir Evaluation. There are at least 14 sources of historical data on the quality of the sediments in OU 3 reservoirs (DOE, 1991). Yet, DOE chose two of these, the 1985 summary of Great Western Reservoir by Rockwell and the 1984 Standley Lake Sediment Sample Collection Summary, also by Rockwell, on which to base the sediment reservoir evaluation program. What criteria were used to make this determination especially given the poor quality of the information available about these studies? It is EPA's position that DOE's strategy for the investigation of reservoir sediment is seriously flawed for the following reasons:

a. The 1985 Rockwell study was evaluated by DOE for data useability and was rejected on all six data useability criteria. This evaluation demonstrated that a risk assessor presented with the results would be unable to perform a quantitative risk assessment, unable to assess exposure pathways, and unable to quantify confidence levels for uncertainty analysis. There is also an increased potential for false negative and false positive results. A program designed to verify this data may succeed given the lack of information about the original study. The conclusion of such a remedial investigation will be equally as unusable.

b. The 1984 Rockwell study was not evaluated by DOE for data useability due to the lack of information about the study. The problems identified above apply to the Standley Lake investigation also.

c. The sampling design described in the final OU 3 work plan used different sampling techniques than the ones used in the previous studies. Therefore, the results will not be comparable, and it is technically incorrect to combine data from the old and new studies.

d. Any attempt to use historical data must include calculation of confidence intervals for each new data point.

DOE has shown in Section 6.3.1.2 of the final work plan that to achieve an 80 percent power, 62 samples are required for Great Western Reservoir and 56 samples are required for Standley Lake. Given the unacceptable quality of the historical studies of these reservoirs, the OU 3 remedial investigation must be designed to collect 62 new sediment samples from Great Western Reservoir and 56 new samples from Standley Lake Reservoir.

Response 3. Section 6, page 28, paragraph 6.3.1.2 Sediment Reservoir Evaluation. As discussed in the meeting with EPA and CDH on January 24, 1992, the data sets selected are the most comprehensive and survey coordinate data are available to locate the samples. Additional data have also been located regarding these data sets that increase the data useability.

The work plan has been modified to describe the statistical approach that will be used to evaluate whether the historical data and the data to be collected are comparable. The statistical rationale for the number of samples necessary to make this comparison is also described in the revised work plan in Section 6.3.1.2. Fifteen samples will be collected in Great Western Reservoir and 18 samples in Standley Lake to confirm the useability of the historical data sets.

Comment 4. Airborne contamination emanating from the solar ponds is a potentially serious health consideration. On page 2-43, the OU 4 RFI/RI work plan states, "Air transmission of potential soil contaminants from the Solar Ponds may occur during the windy, dry periods of the year. Airborne releases may also occur, to a limited extent, during site investigation activities or remedial actions if effective protective measures are not taken." Airborne releases are considered to be the primary pathway of concern in OU 3. To understand airborne contamination in the offsite area, the following five factors must be closely examined:

a. The length and degree of proposed intrusive activities at and near sources of contamination

b. The type of proposed reduction measures of airborne contaminants at the sources

c. The analysis of the present and proposed future composition of the sludge at the solar ponds in particular, including moisture content

d. The emission rates for airborne entrainment of contaminants at the sources to be obtained by appropriate direct measurements or mathematical models

e. The airborne dispersion characteristics of the airborne contaminants to be generated by appropriate mathematical dispersion models

A more extensive investigation of airborne contamination is needed before the potential health risk can be accurately assessed. EPA expects that the addenda to the final work plan which will describe DOE's proposed air program will include consideration of the above factors. The completeness of the air program cannot be assessed until the addenda to the work plan is reviewed.

Response 4. As discussed in the January 24, 1992 meeting with EPA and CDH, the issues regarding air should be addressed at each specific OU or in the sitewide air program. The approach presented in the OU 3 Work Plan is based on the OU conceptual model that relates sources, release mechanisms and receptors. An addendum to the work plan describing the details of the air sampling program will be submitted to EPA for approval and will address some of the issues presented by EPA. However, the general air sampling program approach will not change.

Comment 5. The following comments pertain to Section 8, the Environmental Evaluation Work Plan and Field Sampling Plan:

Comment Page 8-3. Paragraph 1. Text appears to be missing from the second sentence.

Response Page 8-3. Paragraph 1. Comment noted and text has been edited.

Comment Page 8-14, Paragraph 2. The text states that radionuclides and metals are the Contaminants of Concern (COC) for OU 3 and that RFP-related organic compounds are not expected to be present at OU 3. Table 8-5, however, identifies several organic compounds that have been detected in samples from OU 3 at concentrations exceeding the application or relevant and appropriate requirements (ARARs). The reasons for not considering these compounds as COCs should be discussed because they have been identified in RFP samples and meet the criteria to be used for COC identification. If laboratory contamination is suspected, this should be evaluated quantitatively.

Response Page 8-14, Paragraph 2. The organic compounds identified in Table 8-5 are from samples collected from surface water that originates from sources other than the RFP, i.e., Clear Creek and diverted drainages around the RFP. The source for these organic compounds is not the RFP. A paragraph of explanation has been added to the text. Also, the organic compounds do not appear to occur in quantities known or suspected to produce environmental effects of any type.

Comment Page 8-32, Paragraph 3. The text states that appropriate correction factors must be applied to toxicity test data to account for differences between organisms and conditions in the laboratory versus those of the field. While it is recognized that such differences exist, the test should identify the sources used to develop the correction factors. As written, it appears discussions about the applicability of toxicity data could be arbitrary.

Response Page 8-32, Paragraph 3. When using published information on toxicity tests to evaluate the potential toxicity of onsite media, such as water, the intent is to locate published information that mirrors onsite conditions as closely as possibly. However, the selection of toxicity test data is largely constrained by the availability of published data.

The published data will be thoroughly reviewed for comparability to site conditions and test organisms, and the available toxicity test data will be evaluated using several preestablished criteria. For example:

- Was the toxicity test conducted on the same species as the target species of interest at OU 3?

- Was the toxicity test conducted on the same life stage as the organism of interest at OU 3? Or was the most sensitive life stage used?

- Are the water characteristics (hardness, pH, temperature, etc) used in the toxicity tests similar to the characteristics of the onsite water?

- Are the exposure durations used in the toxicity tests similar to the exposure durations expected for the onsite organism of interest?

Correction or safety factors can be applied based on the degree of differences determined by the risk assessor, following procedures such as those described in EPA (1985b) and Barnthouse et al. (1986). These procedures are usually semiquantitative, and do rely on the professional judgement of the risk assessor. Specific correction factors cannot be preassigned because the process requires that onsite conditions and target species at the location of interest are known (obtained by the field surveys and sampling), and then matched as closely as possible to available toxicity test data.

Other techniques such as sensitivity analyses (EPA, 1989c) or Analysis of Extrapolation Error (Barnthouse et al., 1986) would be used, where appropriate, to provide a measure of the uncertainty involved in the comparisons being made.

Comment Pages 8-40 through 43, Tables 8-3 through 8-5. The tables have columns for regulatory standards that are not listed. The tables should be completed.

Response Page 8-40 through 43. Tables 8-3 through 8-5. These tables are preliminary and incomplete and are an example of the format to be used during implementation of the EE. See page 38, paragraph 1 (sentence 4) and paragraph 2 (sentences 2, 6, 7, and 8) for explanation of the status of these tables.

Comment Pages 8-44 through 8-46, Table 8-6. The table indicates criteria for identification of COCs are applied inconsistently at OU 3. At this stage of the study, the COC list should include all potentially listed contaminants. The exclusion of some with no explanation implies arbitrary selection.

Response Pages 8-44 to 8-46, Table 8-6. See response to pages 8-40 through 8-43. The tables for criteria for identification of COCs will be extensively revised during implementation of the EE.

Comment Page 8-63, Paragraph 3. The text identifies potential transport media to OU 3 biological receptors as air, soil, surface water, and sediments. Although biological access to ground water is generally limited, the existence of springs containing RFP-contaminated groundwater has not be eliminated as a potential exposure point, and is discussed as page 8-95. Therefore, ground water should not be eliminated as a transport medium.

Response Page 8-63, Paragraph 3. The initial site visit and reconnaissance did not identify springs and seeps that were considered directly related to groundwater from the RFP. The few seeps located were small and localized below irrigation and conveyance ditches or reservoir embankments, and are probably not related to the regional groundwater system. Provisions are made in the OU 3 sampling plan to locate and sample springs within OU 3 if they are present or if they are in hydraulic communication with RFP groundwater.

Comment Page 8-83, Paragraph 3. The text states that the EE report will include a summary section. Table 8-9 does not show such a summary section, however. The table should be revised to include all anticipated sections.

Response Page 8-83, Paragraph 3. Table 8-9 indicates the report will have an Executive Summary. The table has also been revised to include a summary section at the end of the report.

Comment Page 8-85, Paragraph 3. The text states that the initial surveys will be scheduled to coincide with snowmelt or spring storms. The significance of that timing is not clear and should be explained.

Response Page 8-85, Paragraph 3. Surveys versus snowmelt/spring snows. The initial qualitative field surveys of the aquatic ecosystems in the creeks and drainages within OU 3 would be conducted after flows are maintained in the creeks for several weeks. Most of the creeks are dry in the late fall and winter, and a period of flowing water must occur to reestablish the conditions conducive to aquatic organisms. The intent is to wait until water has been consistently flowing for several weeks, but sample before the next dry period starts. The text has been revised appropriately.

Comment Page 8-91, Figure 8-7. The terrestrial habitat types are not defined for large areas of OU 3. While the initial map is considered preliminary, it is not clear whether all habitat types (including disturbed or developed by man) will be identified for all of OU 3. This should be clarified in the text.

Response Page 8-91, Figure 8-7. The large areas on the terrestrial habitat map left undefined are agricultural, commercial, or residential areas that have no habitat. The map legend will be altered to reflect this and the final mapping will include land use classification in addition to habitat mapping.

Comment Page 8-101, Paragraph 3. The discussion states that vegetation quadrant locations may be placed in areas of accumulation or may be rejected if they are not representative of the local vegetation. The work plan states the intent to use standard statistical analyses to evaluate data. The proposed analyses are based on the concept of randomness. The proposed selection or rejection of sample locations eliminates randomness and should be reconsidered before fieldwork is initiated.

Respond Page 8-101, Paragraph 3. The placement and location of quadrants is based first on areas of relatively homogeneous vegetation. Within the defined boundaries, placement will use a random stratified method of locating quadrants. Since natural vegetation is often a complex mosaic of types, and may include disturbance (roads, railroads, animal burrows, etc.), a quadrant location may be rejected if it will not be a sample that is part of a statistically valid population.

Comment Page 8-107, Table 8-12. Although collection of terrestrial mammal tissue samples is discussed in the text, such samples are not identified in the table. Analysis of terrestrial vegetation for metal content is not listed and a rationale for its exclusion is not provided. The text and table should be revised to provide more information behind decisions apparently made at this early stage of the study.

Response Page 8-107, Table 8-12. Terrestrial mammalian tissue sample analyses have been added to Table 8-12. Metals content in vegetation and small mammals is not sampled since soils are not sampled for metals and no significant pathways exists from sources at the RFP. See Section 6.2.2.4, Soils for COC Discussion.

Comment Page 8-106, Paragraph 2. The text states that sacrificed animals will be placed in glass sample containers. Observations of RFP sampling indicate that plastic bags are more likely sample containers. The sample handling procedures should be reevaluated.

Response Page 8-106, Paragraph 2. Glass sample containers for animals are specified in the SOP, Volume 5, Section 5.6. If experience has shown that plastic bags are more appropriate containers, then the SOP and the sampling procedures for OU 3 will be revised. Table 8-12 has been revised so glass or plastic could be used.

Comment Page 8-119, Paragraph 3. The discussion of benthic macroinvertebrates includes the statement that *Ceriodaphnia* will be used in toxicity tests. *Ceriodaphnia* is not a benthic organism and the reason for inclusion of this statement at this point in the text is not clear. The text should be expanded to explain its inclusion or the statement should be moved to the discussion of toxicity testing.

Response Page 8-119, Paragraph 3. The last sentence in paragraph 3 regarding toxicity tests with *Ceriodaphnia* should be deleted.

The discussion of toxicity testing in Sections 8.2.4—Toxicity Assessment and 8.2.9—Ecotogicological Investigations adequately describe the toxicity testing approach proposed.

The intent is to use standardized acute and chronic tests with fathead minnows and *Ceriodaphnia* (zooplankton) to run the initial tests. If these proven consensus methods indicate the aquatic system may be toxic, additional tests would be incorporated to evaluate specific media and/or target species.

General Comments

Comment 1. The only major issue that was not addressed in this final version of the OU 3 RFI/RI Workplan is the analysis for metals in the surficial soils. The Division, based on the latest information compiled in the Dose Reconstruction Survey (the CDH/ChemRisk initiative), has decided that the possibility of measurable concentrations of the metal compounds of concern in the offsite surficial soils is very remote. Therefore, we will not press our demand that the soil analysis include metals. However, since DOE has adamantly refused to add metals to the analytical suite for soils, DOE must recognize that at any future time when information becomes available that indicates metals may have contaminated offsite soils, DOE will be liable to investigate and characterize this contamination, no matter what the cost at that time will be. In light of this cost factor, it still seems prudent to us that DOE add that analysis to this investigation.

Response 1. Comment noted.

Specific Comments

Comment Section 1.3.4.2: The values stated in this section for hydraulic conductivity are not representative of values the Division has seen for the geologic units mentioned. In fact, hydraulic conductivities that we have seen for the plant-site indicate that the actual value is at least two orders of magnitude higher.

Response Section 1.3.4.2. Hydraulic conductivity for geologic units at RFP vary widely due to the heterogeneity of the units. Efforts are ongoing to define hydraulic conductivities (EG&G, Geologic Characterization). The work plan has been revised to recognize this variance.

Comment Figure 2-8. The only data point on this map that is germane to the plutonium and americium contamination offsite is data point T-360. However, there is no mean and standard deviation noted for this data point. Please indicate this information or state why it is unavailable.

Response Figure 2-8. Data point T-360 should not have been included on the figure and has been deleted.

DRAWN BY	Douville	CHECKED BY	[signature]	2/15/92	DRAWING NUMBER	RF1068
	02/14/92	APPROVED BY	[signature]	2/18/92		

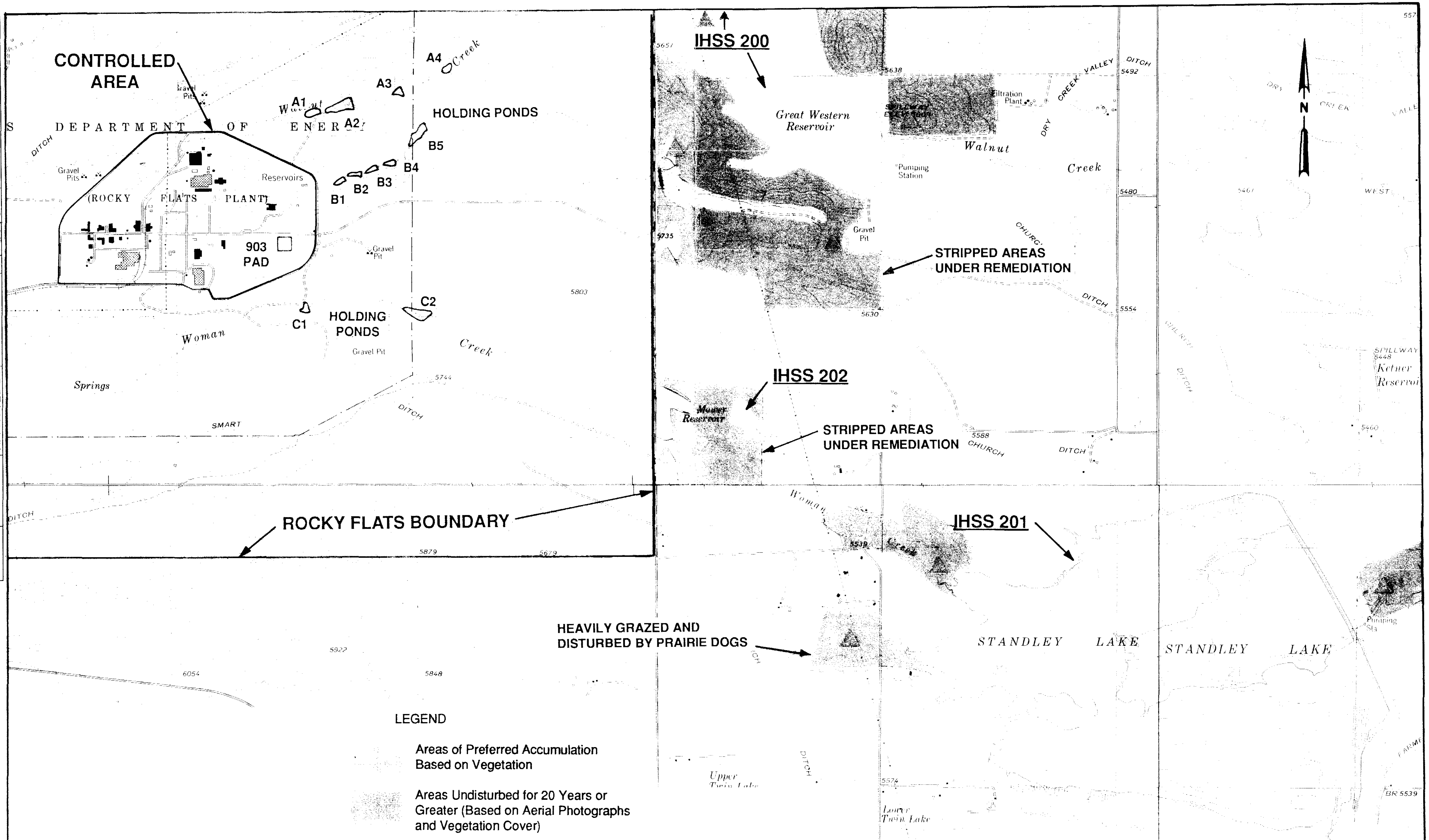


Figure 6-3
Approximate Location of Vertical Soil Profile Samples

DRAWN BY	Douville 11/04/91	CHECKED BY	PBS	12/3/91	DRAWING NUMBER	RF1017
		APPROVED BY	ALL	12/3/91		

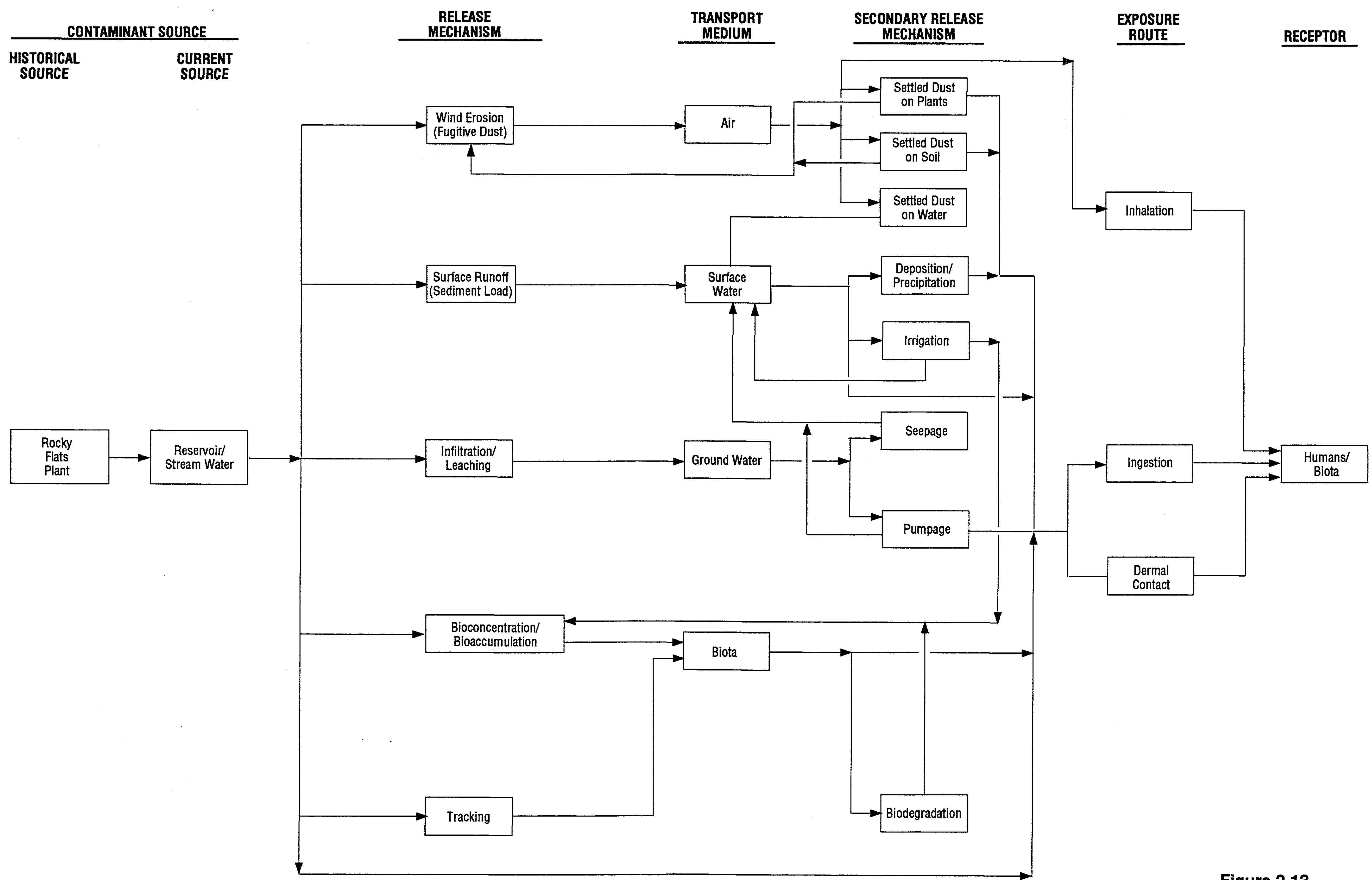


Figure 2-13
GENERAL CONCEPTUAL MODEL
FOR SITE 199

DRAWN BY	KRONER 6-12-91	CHECKED BY	CJR	06-12-91	DRAWING NUMBER	304923-B14
		APPROVED BY	CJR	06-12-91		

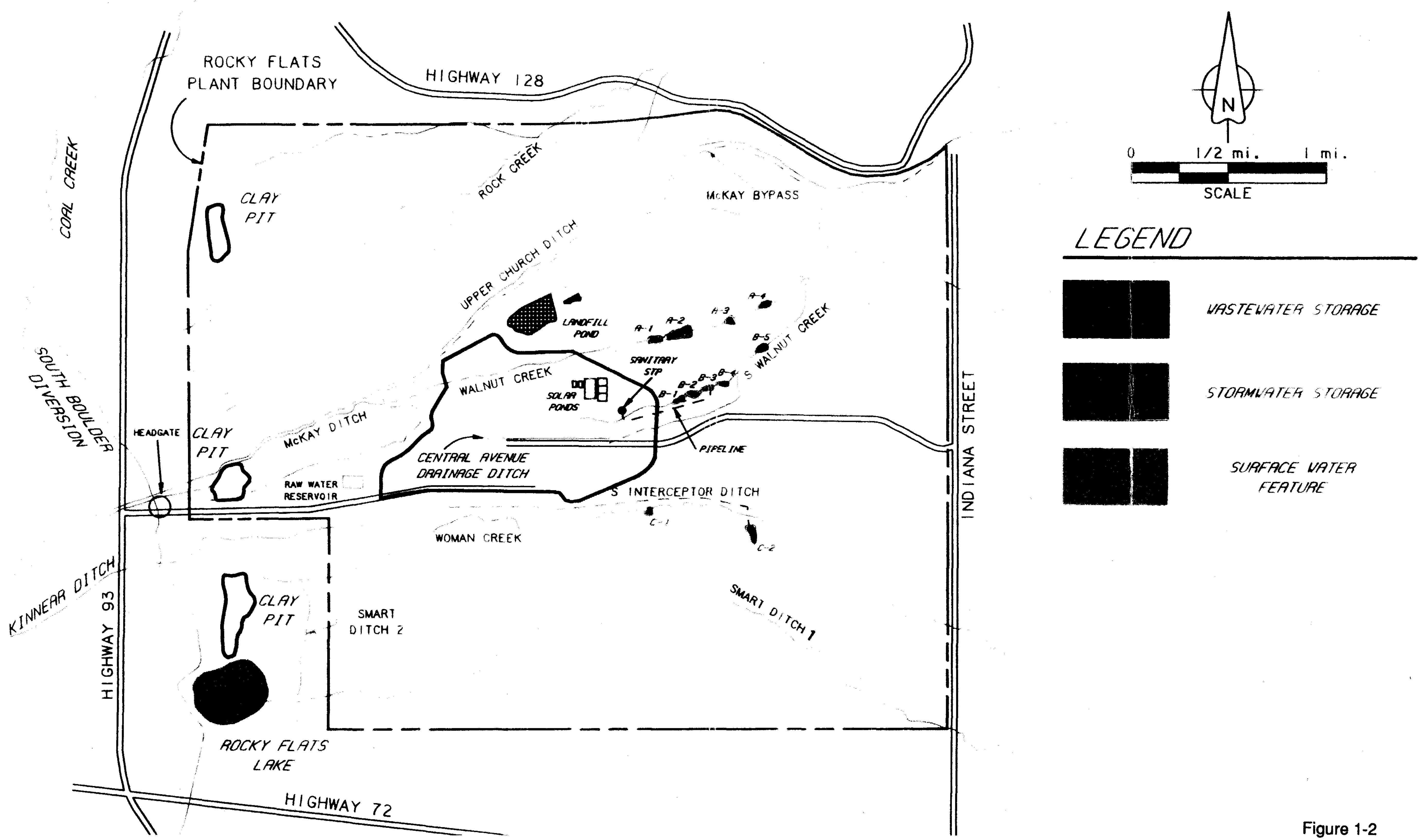


Figure 1-2
Upstream and Onsite Surface Water Features

SOURCE: DRAFT ROCKY FLATS SURFACE WATER MANAGEMENT PLAN, MARCH 1991.

492381

DRAWN BY	KRONER 6-12-91	CHECKED BY	CJR	06-12-91	DRAWING NUMBER	304923-B15
		APPROVED BY	CJR	06-12-91		

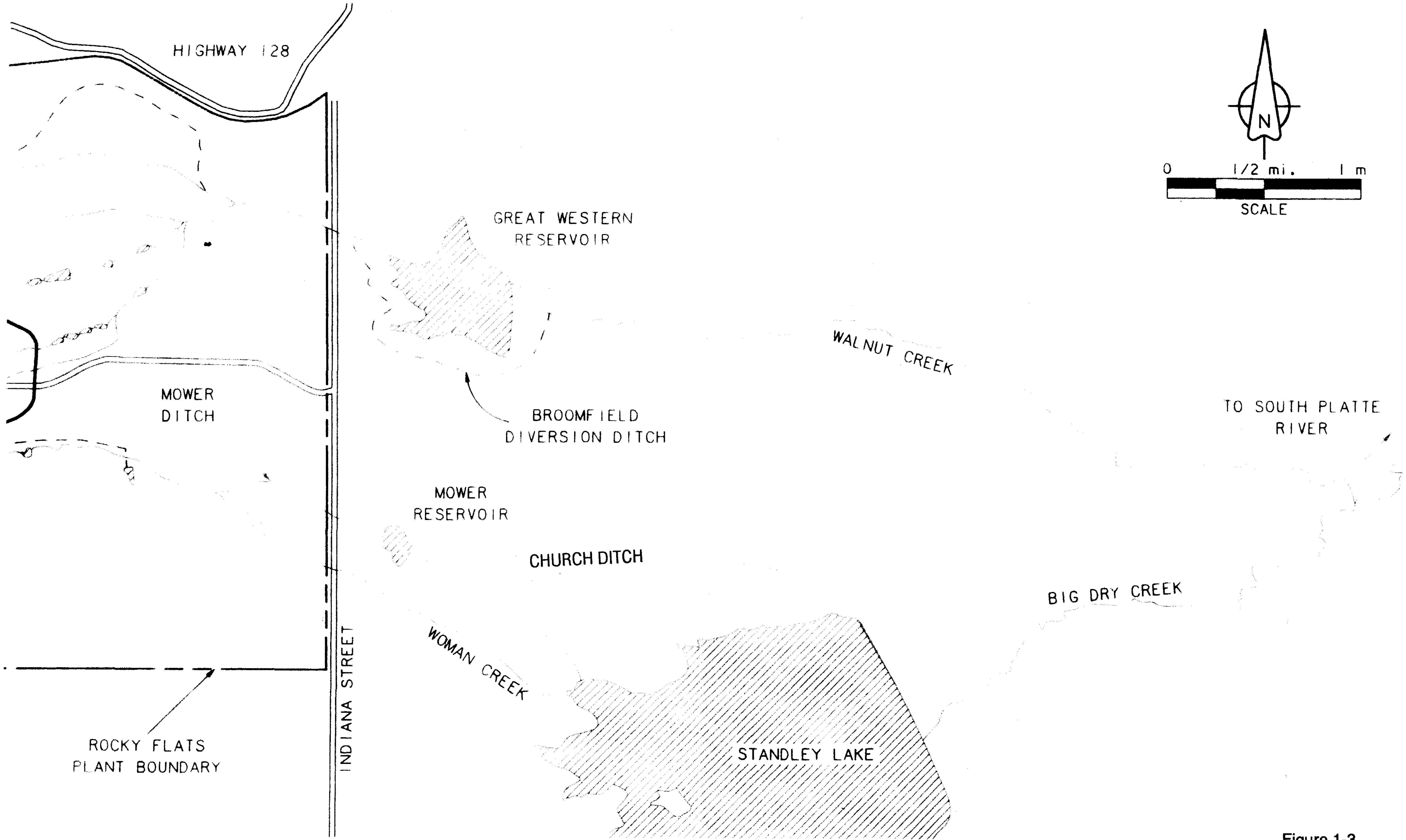


Figure 1-3
Downstream Surface Water Features

SOURCE: DRAFT ROCKY FLATS SURFACE WATER MANAGEMENT PLAN, MARCH 1991.

492381

DRAWN BY	Douville 02/14/92	CHECKED BY / APPROVED BY	PBS / ALL	2/17/92 / 2/18/92	DRAWING NUMBER	RF10

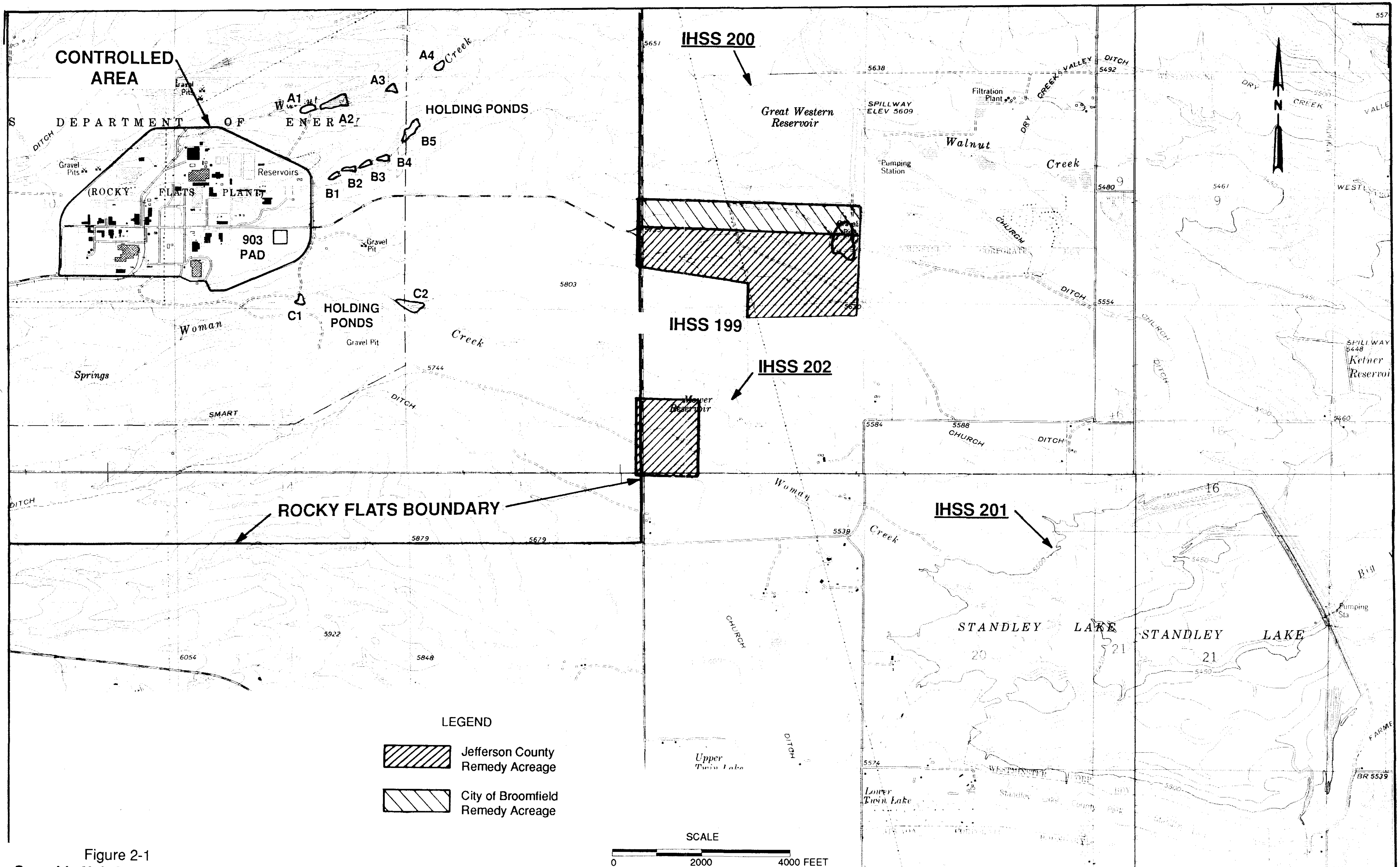


Figure 2-1
Operable Unit 3 Location Map

DRAWN BY	Douville 10/22/91	CHECKED BY	PBS	11-25-91	DRAWING NUMBER	RF1018
		APPROVED BY	ALL	11-25-91		

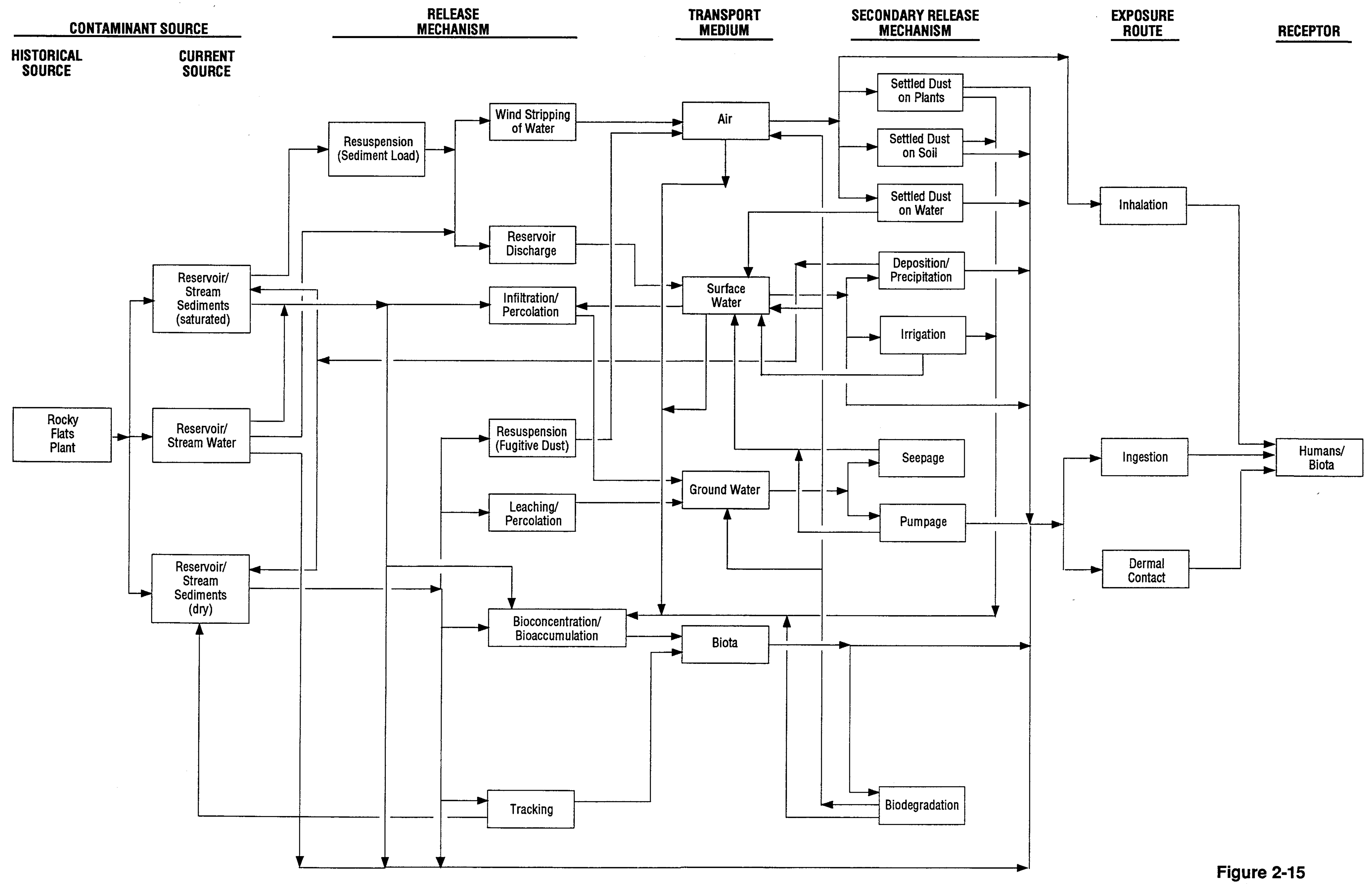


Figure 2-15
GENERAL CONCEPTUAL MODEL FOR SITES 200-202

DRAWN BY	Douville 11/07/91	CHECKED BY	REM 11/07/91	DDS 2-18-92	DRAWING NUMBER	RF1031
		APPROVED BY	A. [illegible]	2-18-92		

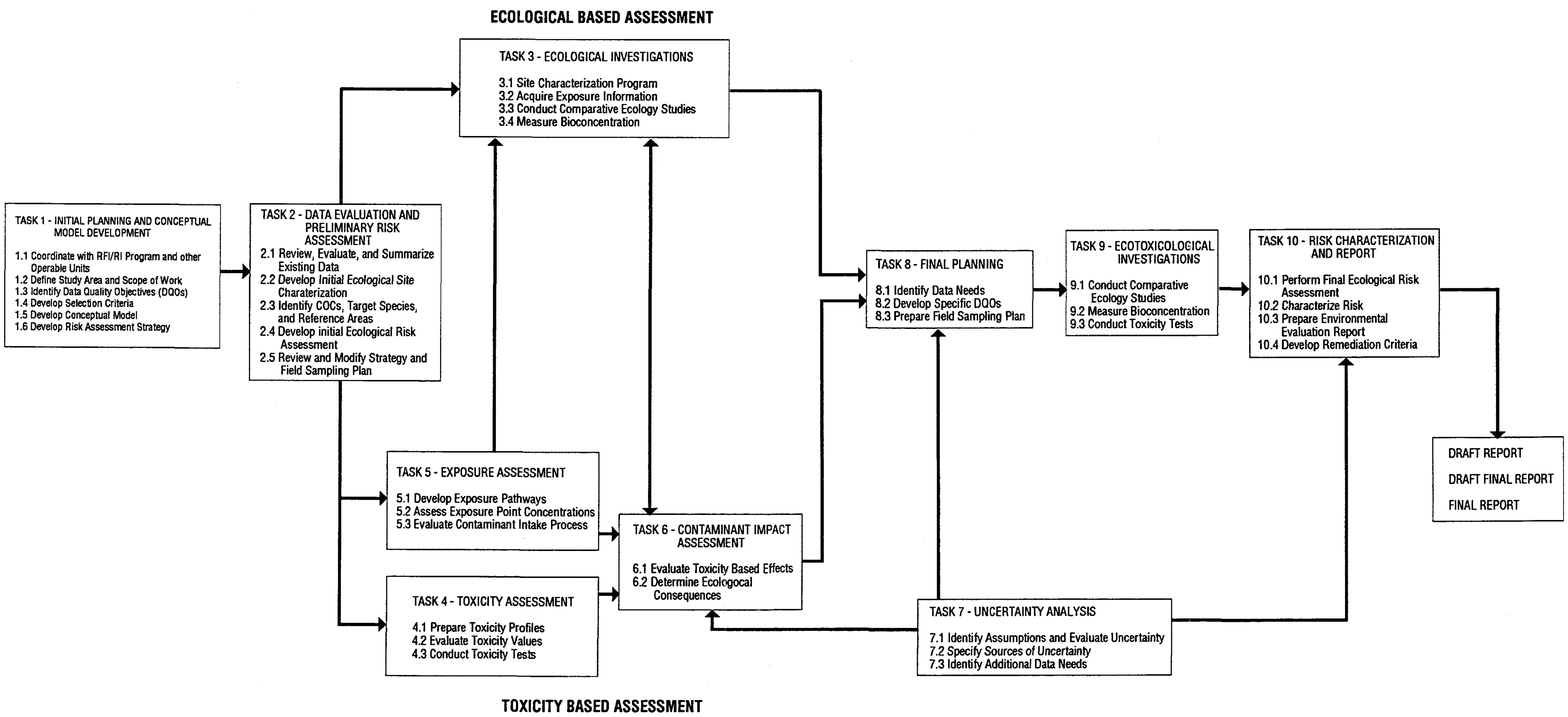


Figure 8-1
Interrelationships Between Tasks for the Environmental Evaluation at Operable Unit 3

DRAWN BY	Douville 11/06/91	CHECKED BY	~~REM 11/07/91~~	PBS 12/3/91	DRAWING NUMBER	RF1034	
		APPROVED BY	A. ~~Lange 11/25/91~~	ACL 12/3/91			

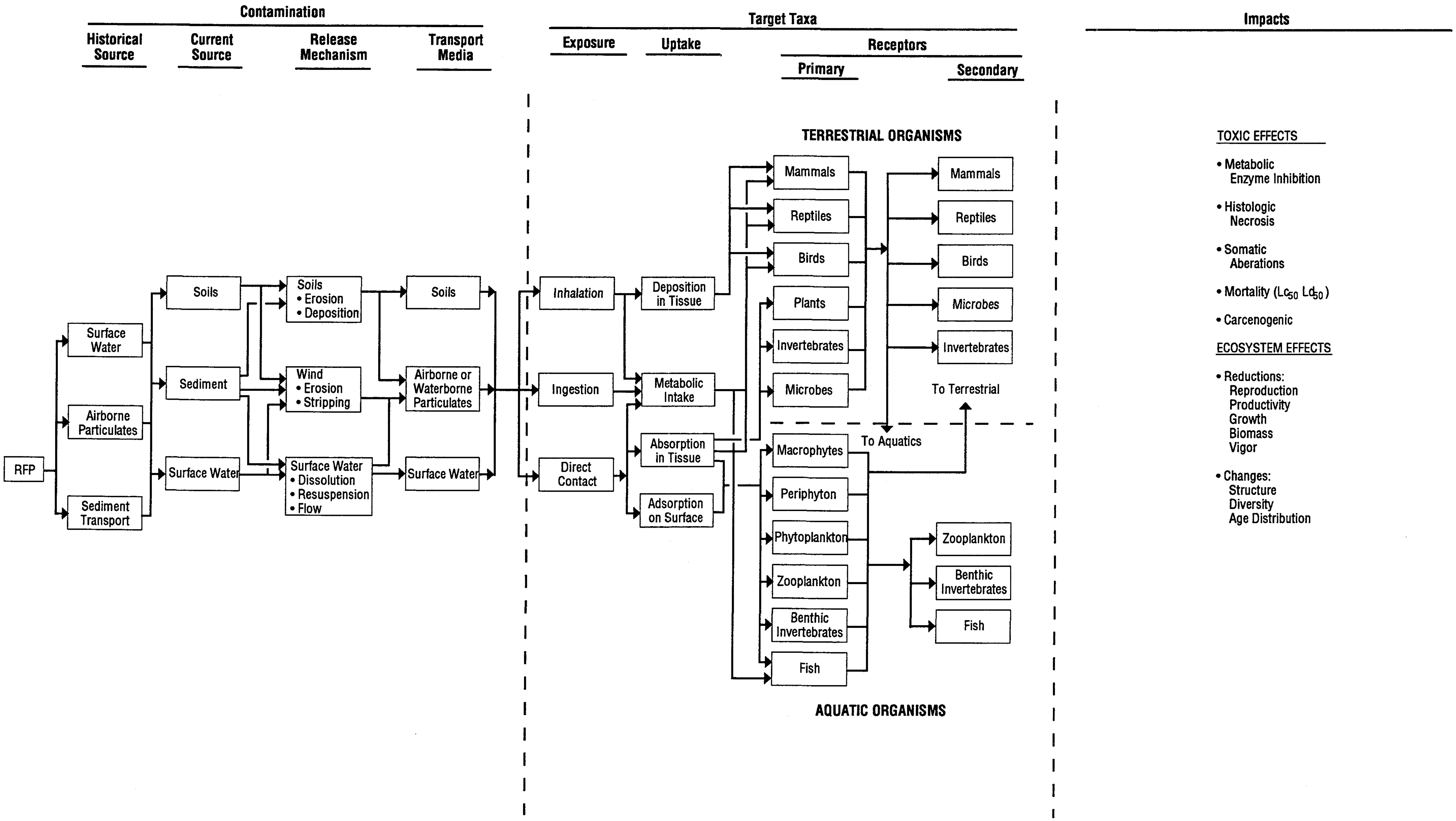
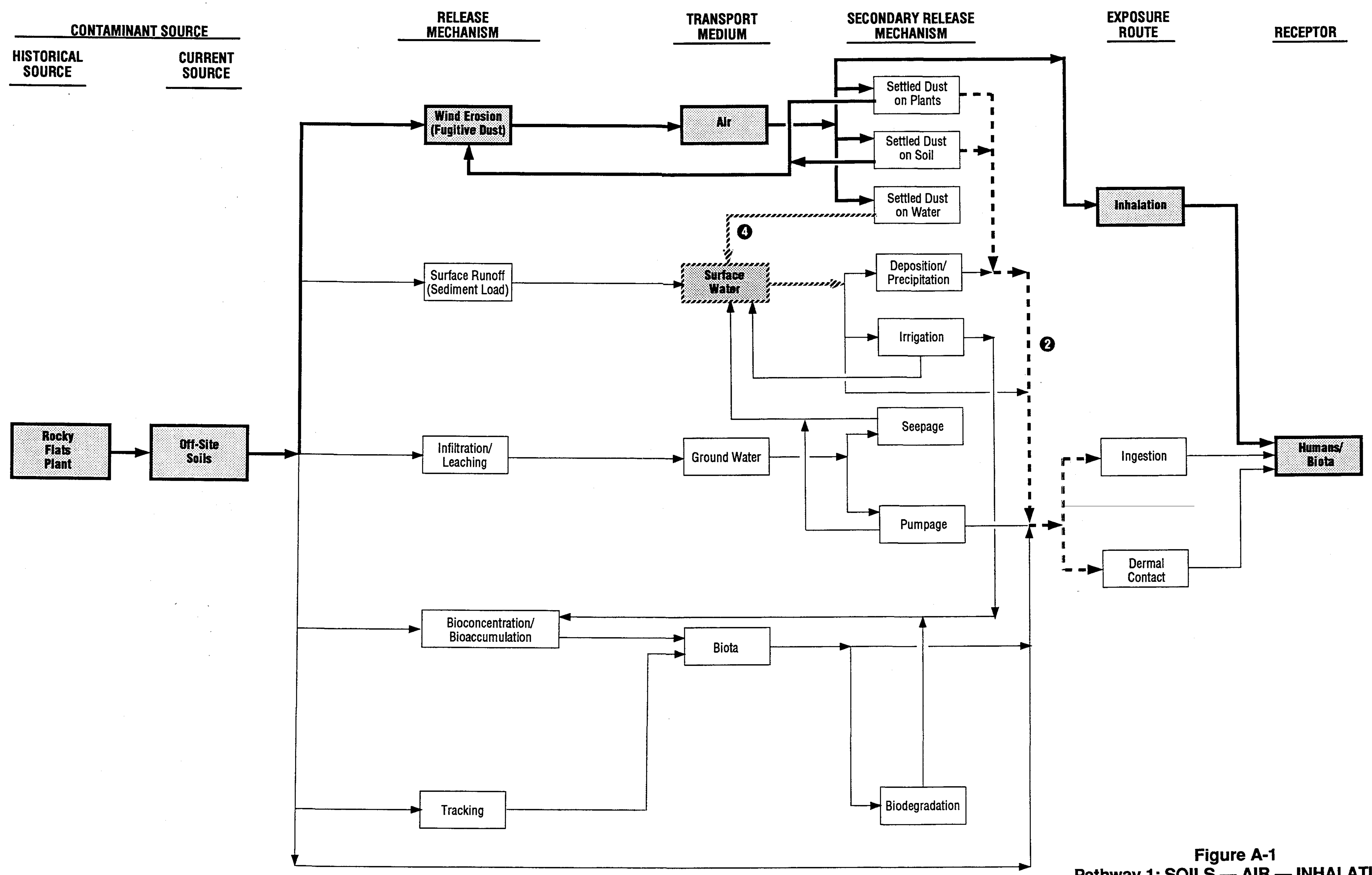


Figure 8-3
Conceptual Model Diagram for the Environmental Evaluation at Operable Unit 3

DRAWN BY	Douville 10/23/91	CHECKED BY / APPROVED BY	A. Lange / ALL	10/25/91 / 11/25/91	DRAWING NUMBER RF1004



❹ ❷ - Other Pathways Addressed

Figure A-1
Pathway 1: SOILS — AIR — INHALATION
General Conceptual Model
for Site 199

DRAWN BY	Douville	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1005
	10/22/91	APPROVED BY	RLL	11/25/91		

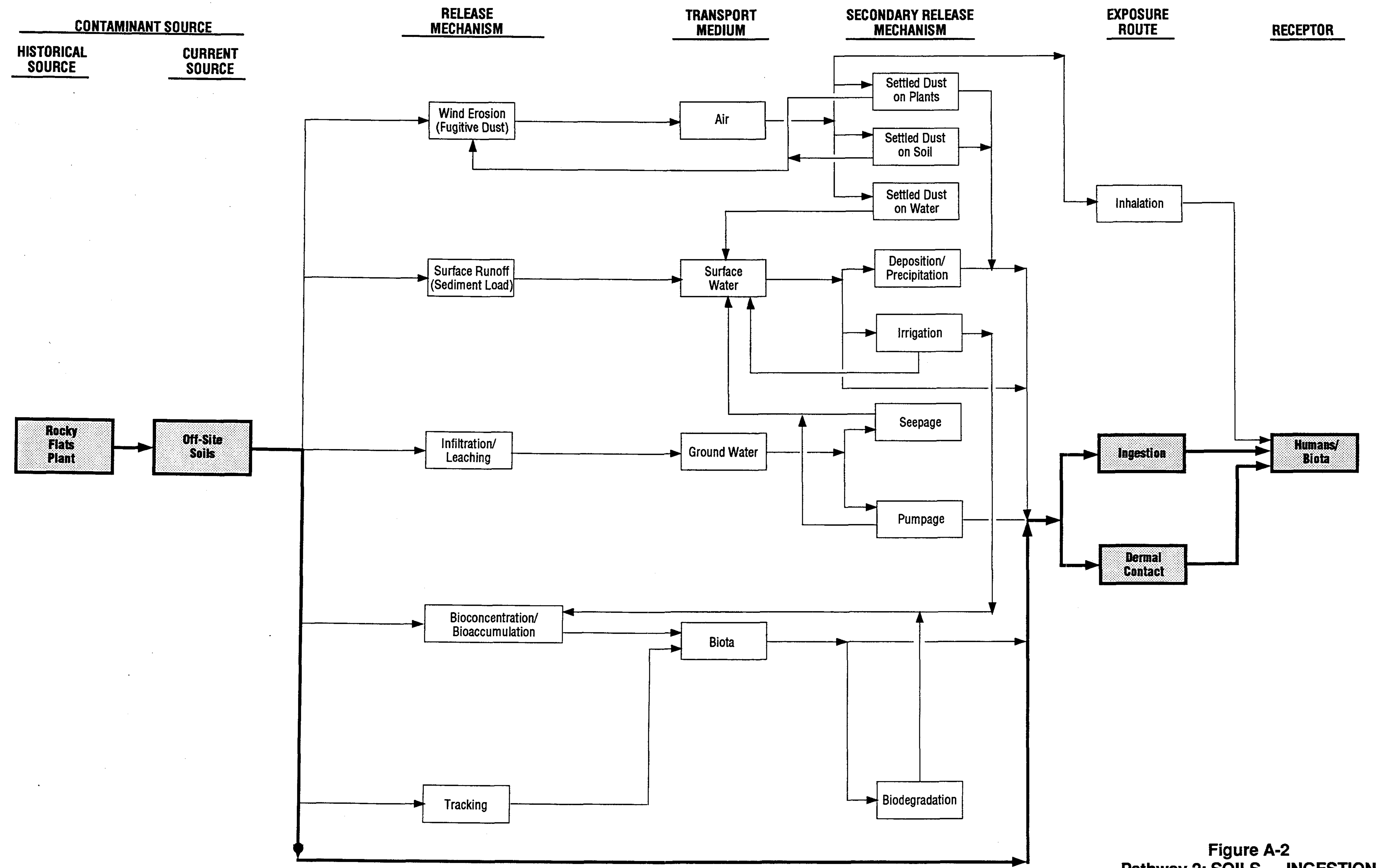


Figure A-2
Pathway 2: SOILS — INGESTION
General Conceptual Model
for Site 199

DRAWN BY	Douville 10/23/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1006
		APPROVED BY	ALL	11/25/91		

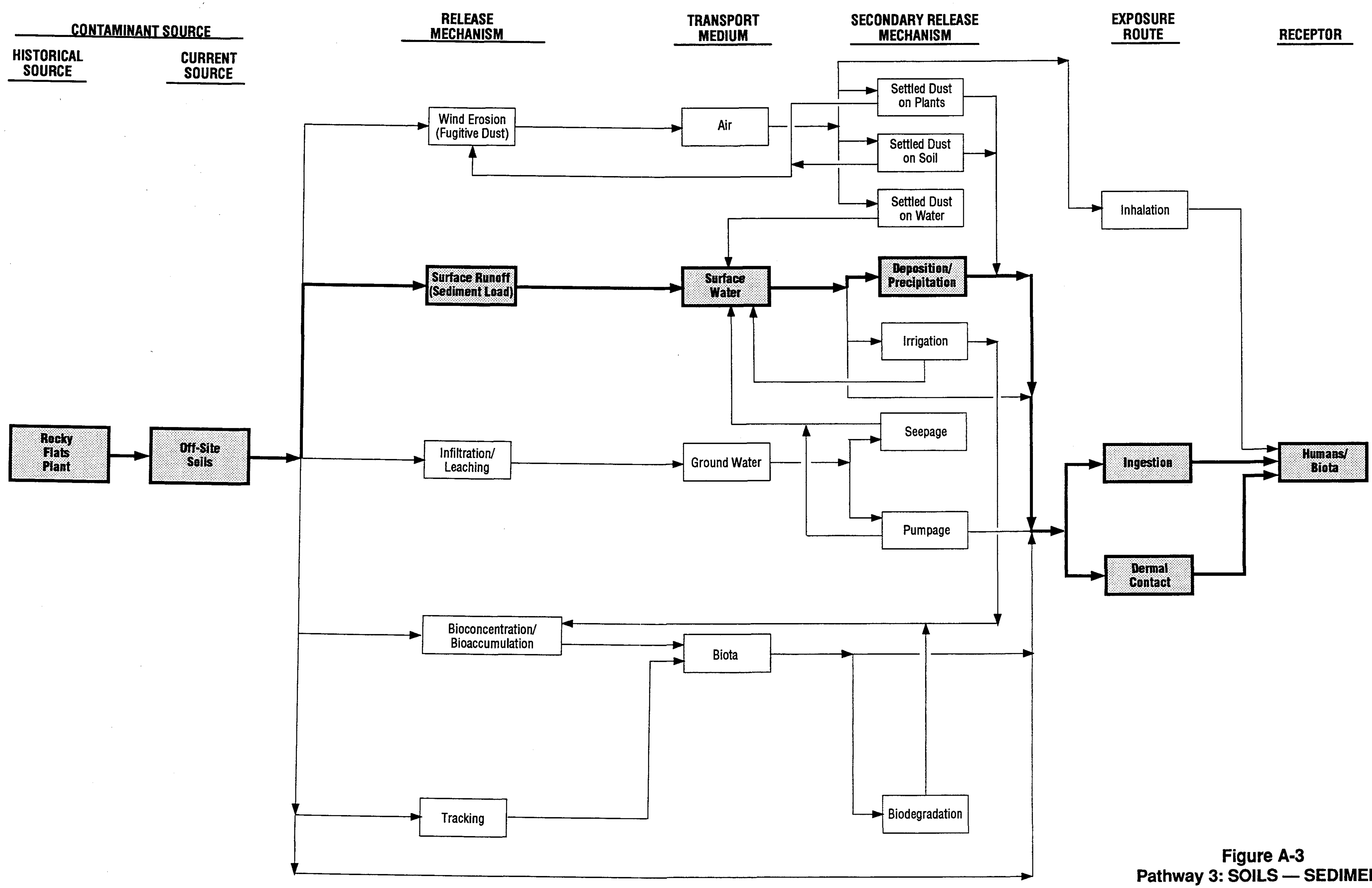
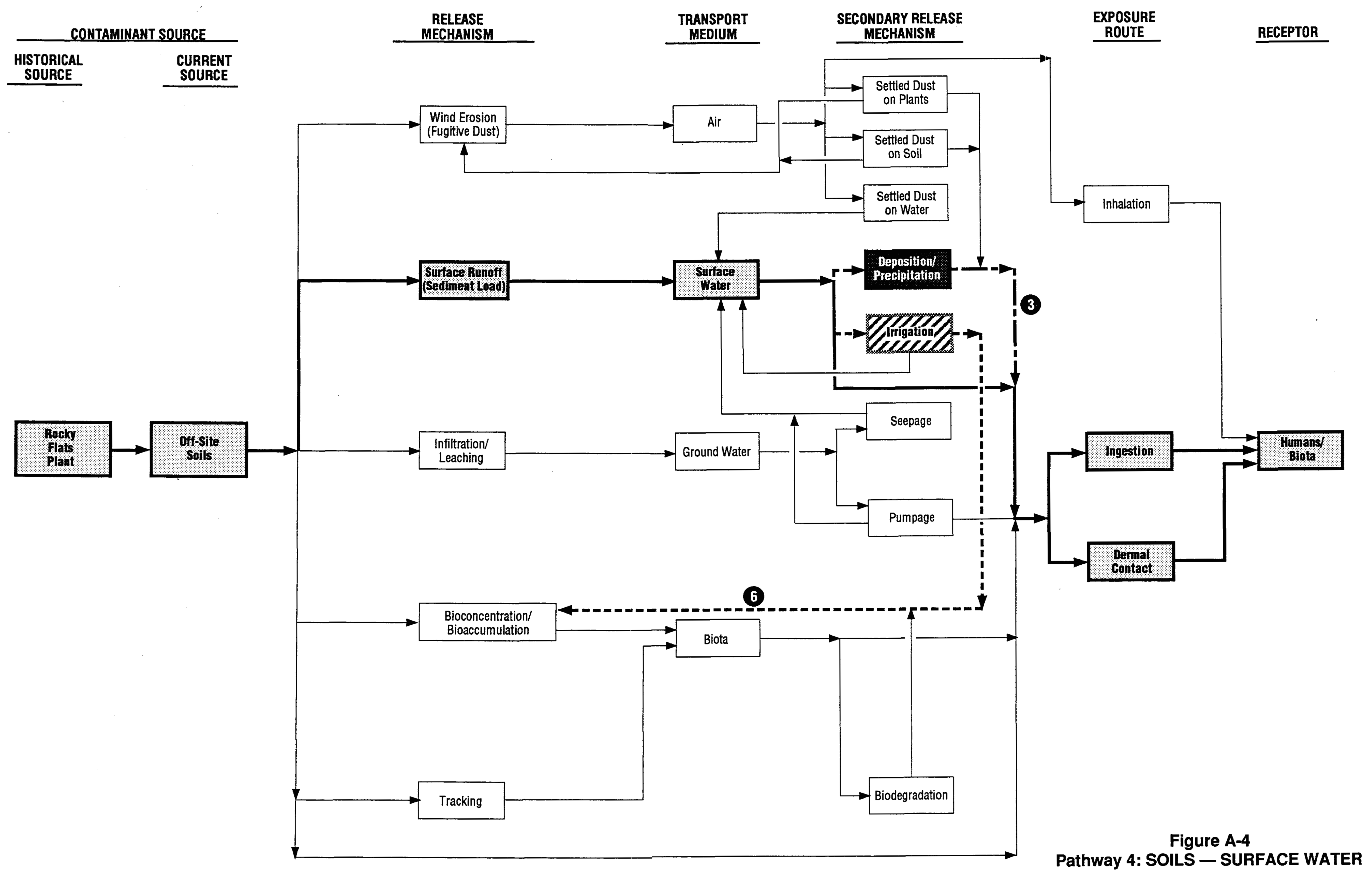


Figure A-3
Pathway 3: SOILS — SEDIMENT
General Conceptual Model
for Site 199

DRAWN BY	Douville 10/23/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1007
		APPROVED BY	AL	11/25/91		



6 3 - Other Pathways Addressed

Figure A-4
Pathway 4: SOILS — SURFACE WATER
General Conceptual Model
for Site 199

DRAWN BY	Douville	10/23/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER RF1008
			APPROVED BY	ALL	11/25/91	

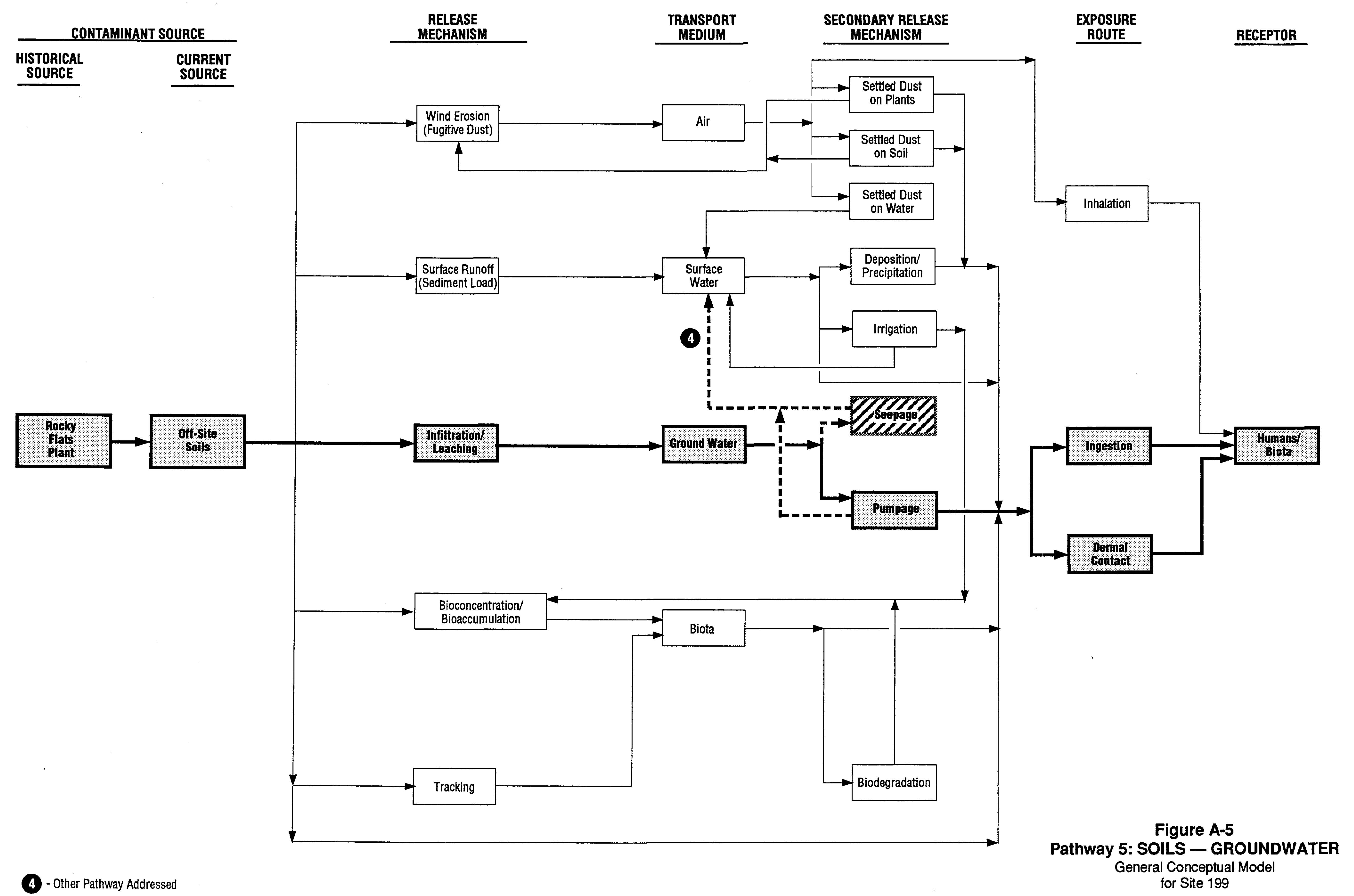


Figure A-5
Pathway 5: SOILS — GROUNDWATER
General Conceptual Model
for Site 199

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1009
		APPROVED BY	ALL	11/25/91		

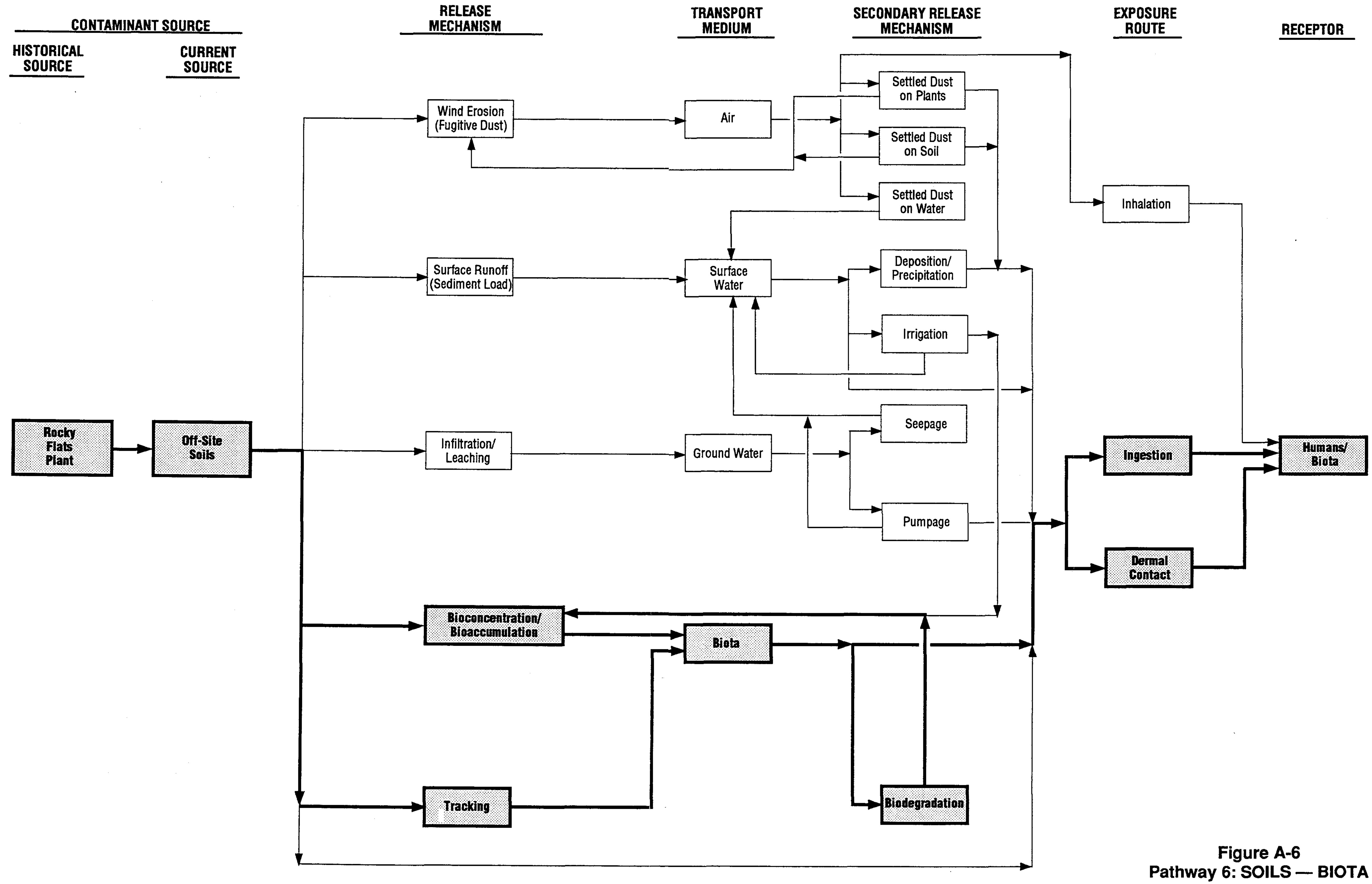


Figure A-6
Pathway 6: SOILS — BIOTA
General Conceptual Model
for Site 199

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1010
		APPROVED BY	AL	11/25/91		

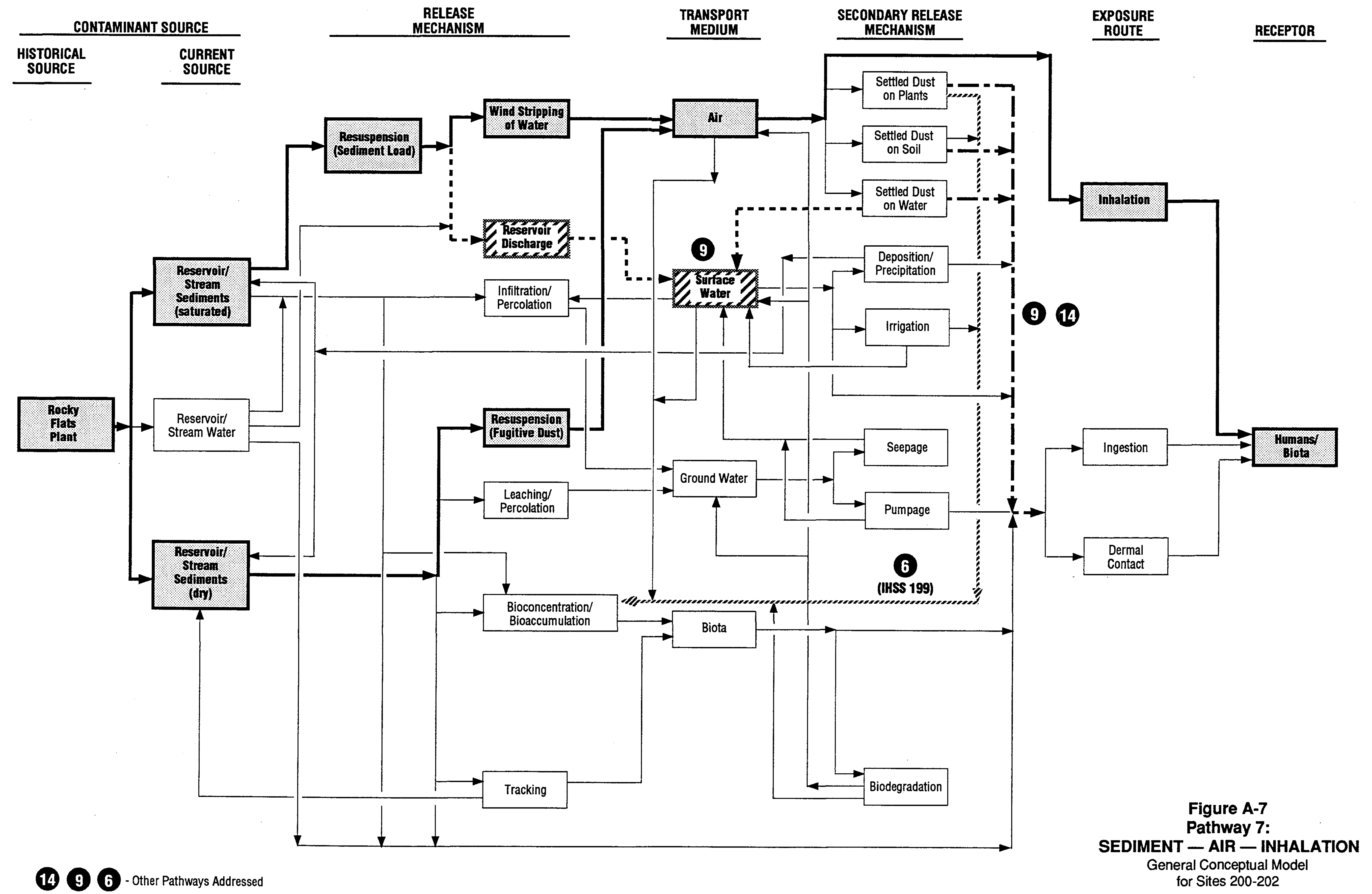


Figure A-7
Pathway 7:
SEDIMENT — AIR — INHALATION
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1011
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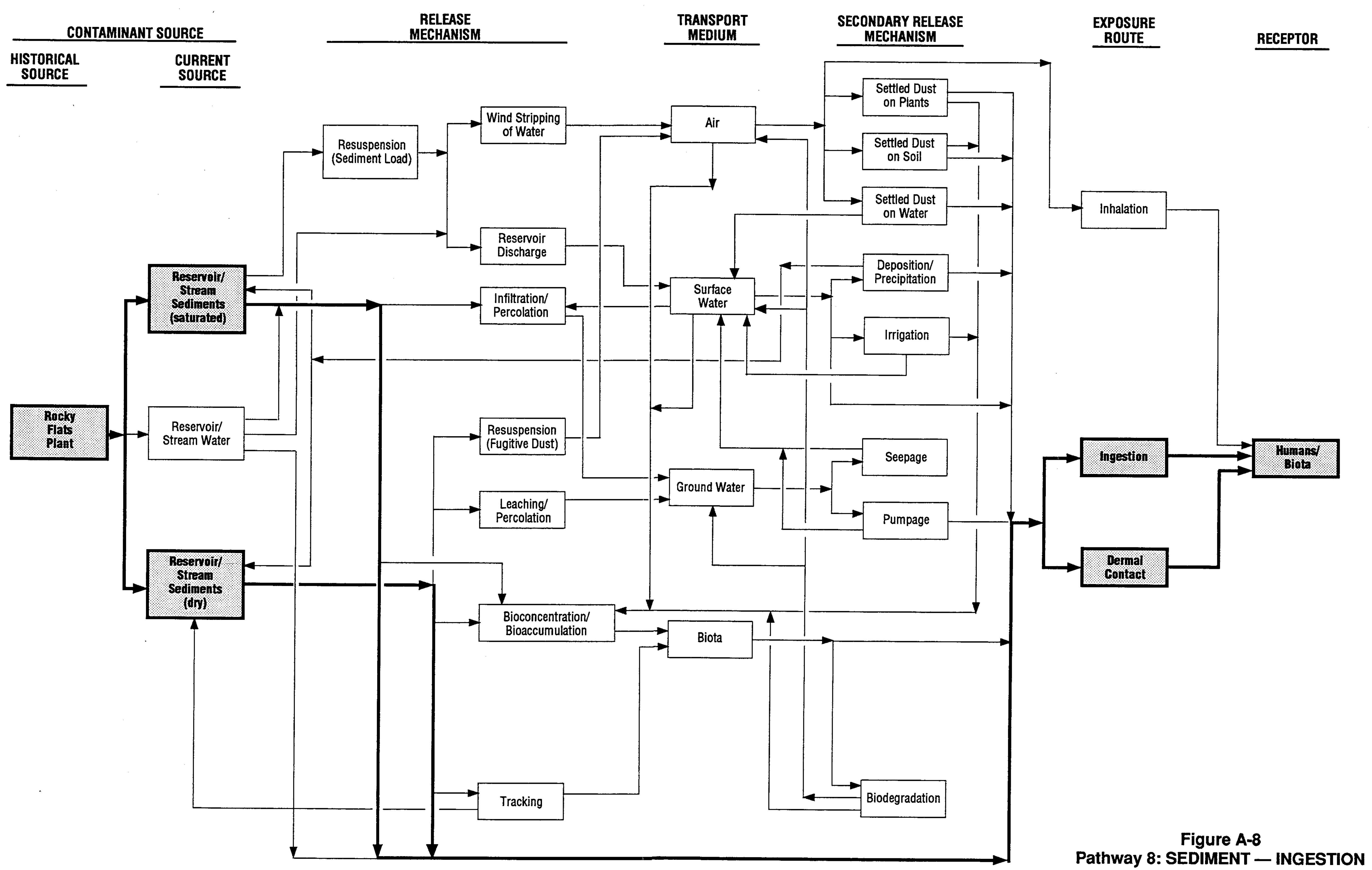


Figure A-8
Pathway 8: SEDIMENT — INGESTION
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY / APPROVED BY	A. Lange / ALL	10/25/91 / 11/25/91	DRAWING NUMBER	RF1012

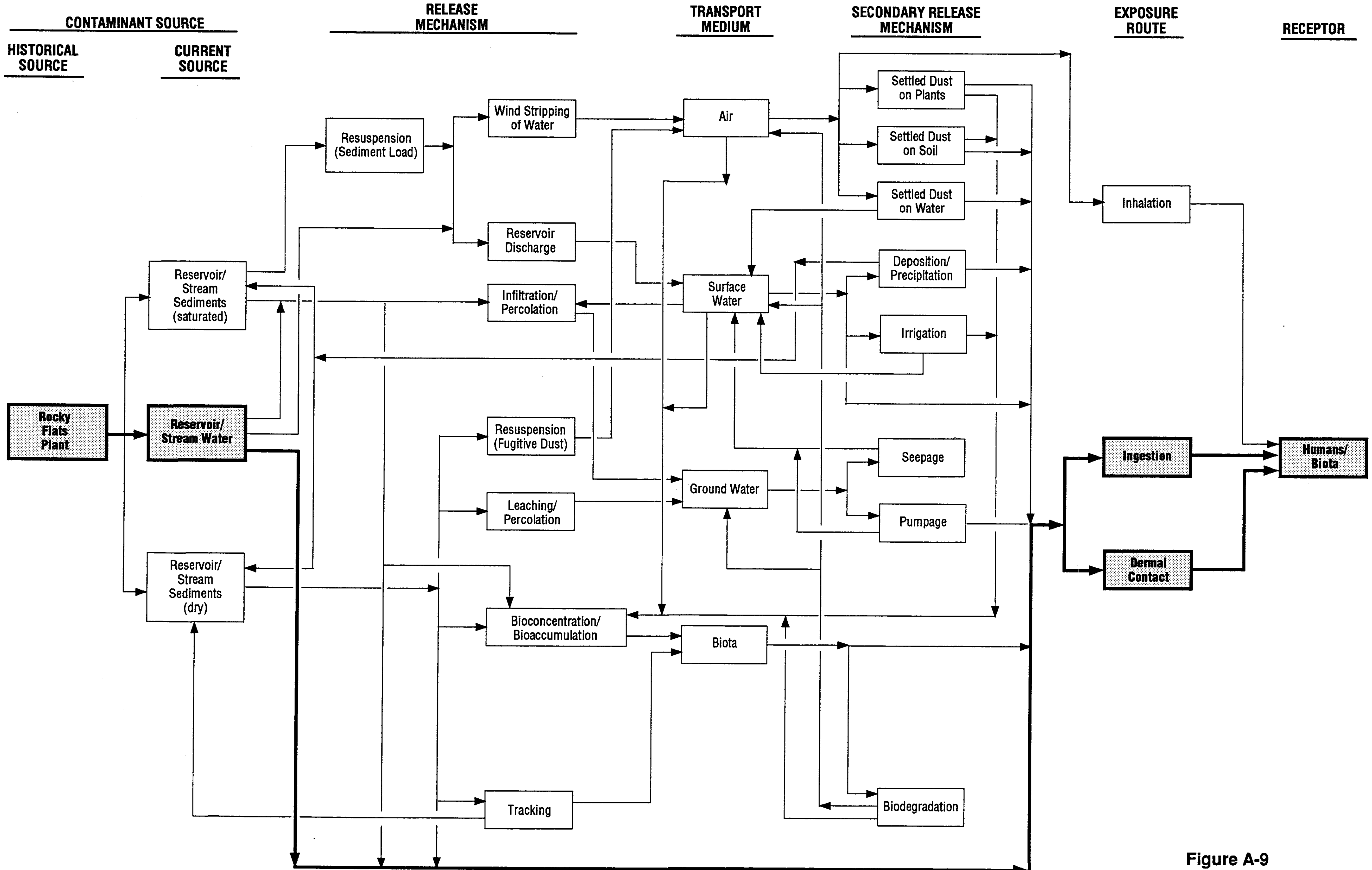
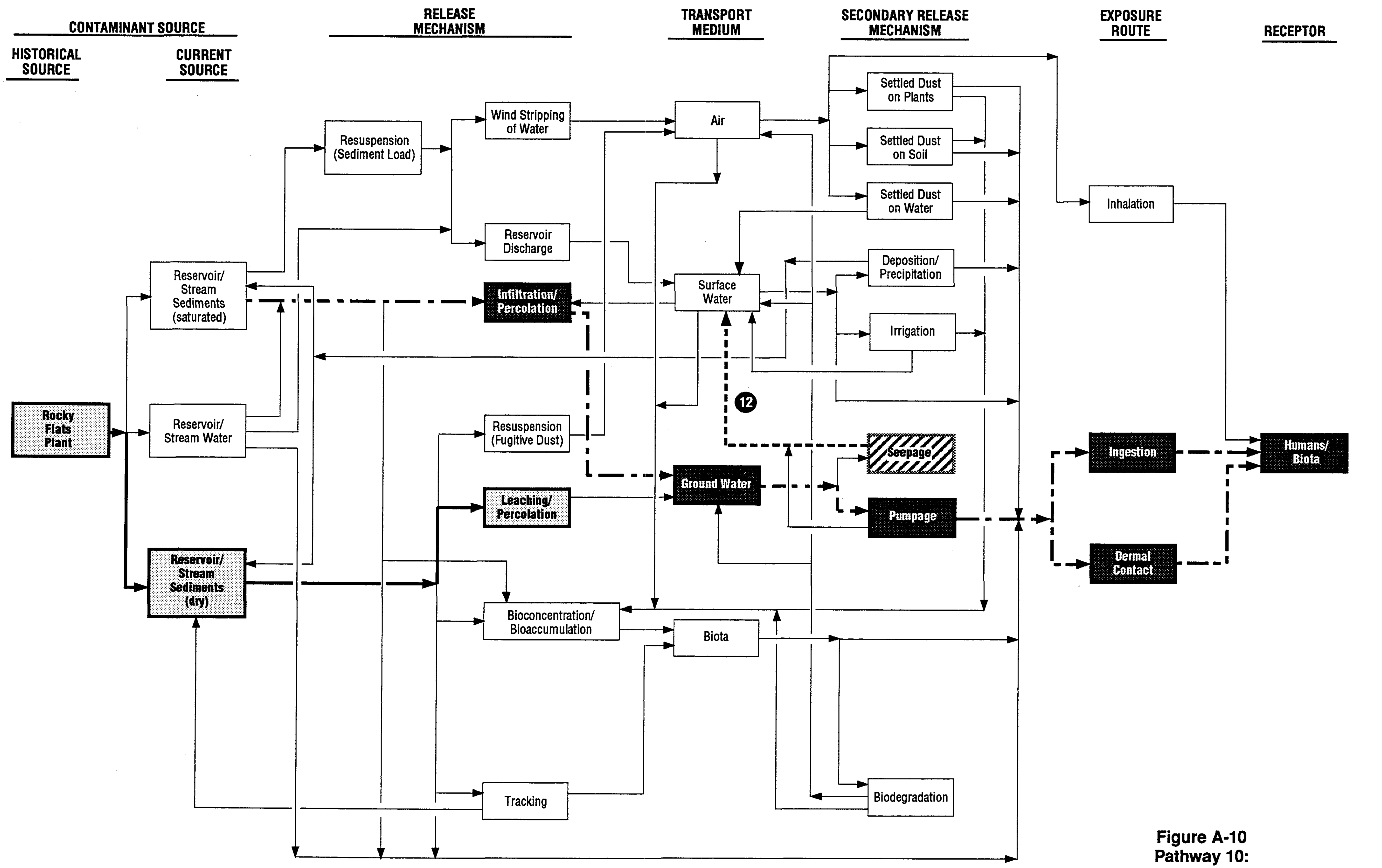


Figure A-9
Pathway 9: SURFACE WATER — INGESTION
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1013
		APPROVED BY	ALL	11/25/91		



12 - Other Pathway Addressed

Figure A-10
Pathway 10:
SEDIMENT — GROUNDWATER — INGESTION
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1015
		APPROVED BY	ALL	11/25/91		

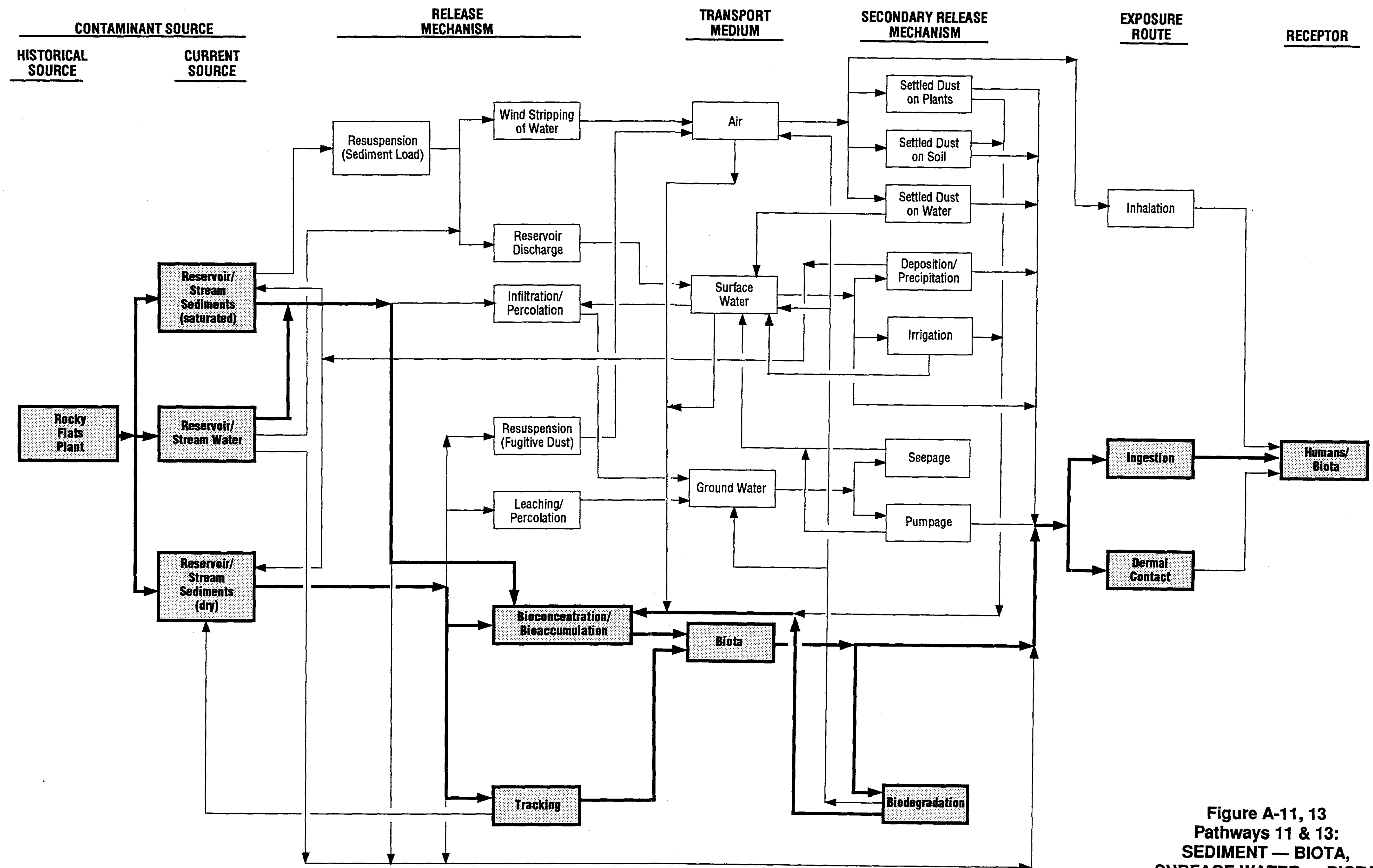
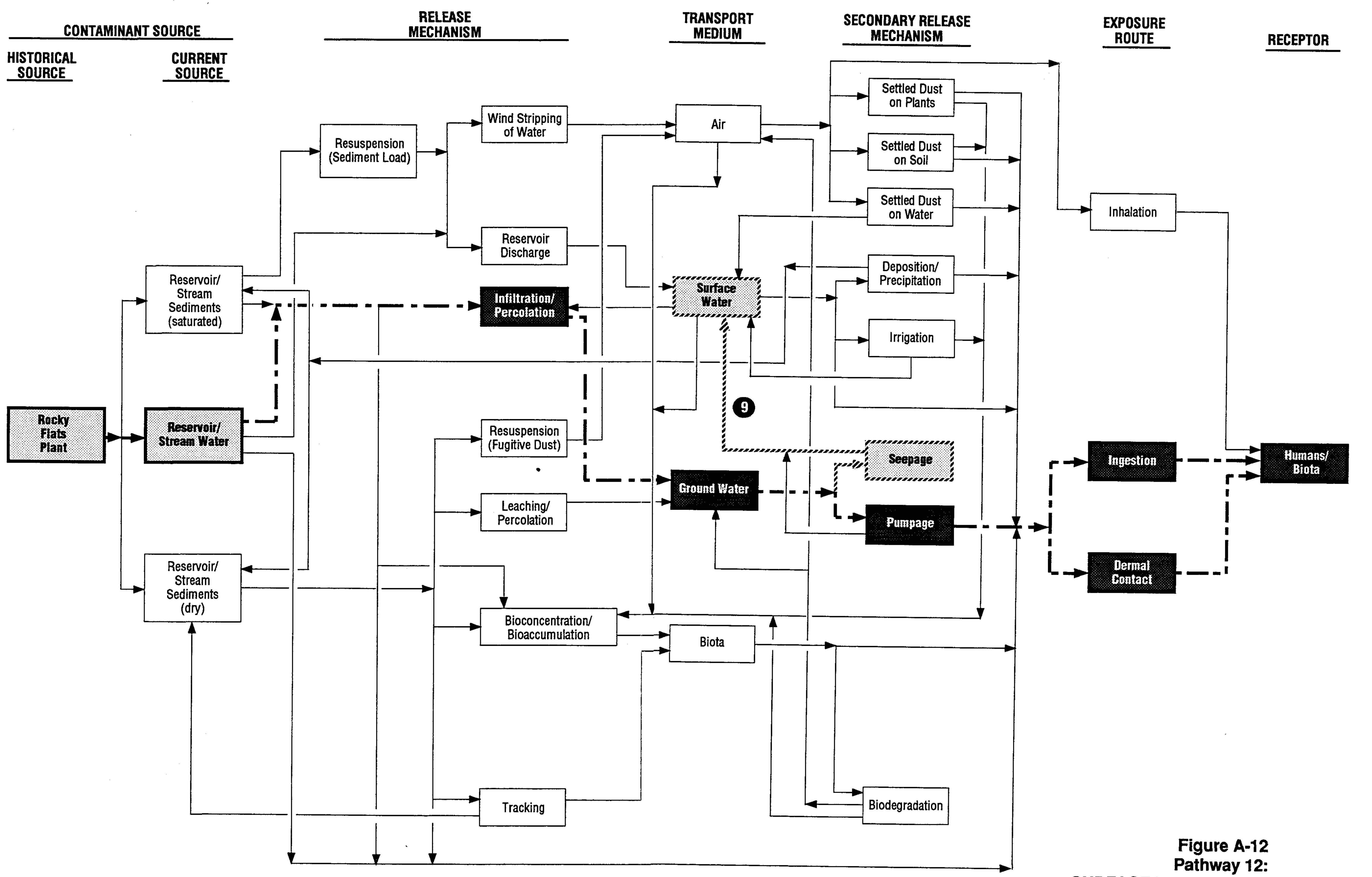


Figure A-11, 13
Pathways 11 & 13:
SEDIMENT — BIOTA,
SURFACE WATER — BIOTA
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY / APPROVED BY	A. Lange / ALL	10/25/91 / 11/25/91	DRAWING NUMBER	RF1016



9 - Other Pathway Addressed

Figure A-12
Pathway 12:
SURFACE WATER — GROUNDWATER
General Conceptual Model
for Sites 200-202

DRAWN BY	Douville 10/22/91	CHECKED BY	A. Lange	10/25/91	DRAWING NUMBER	RF1014
		APPROVED BY	AL	11/25/91		

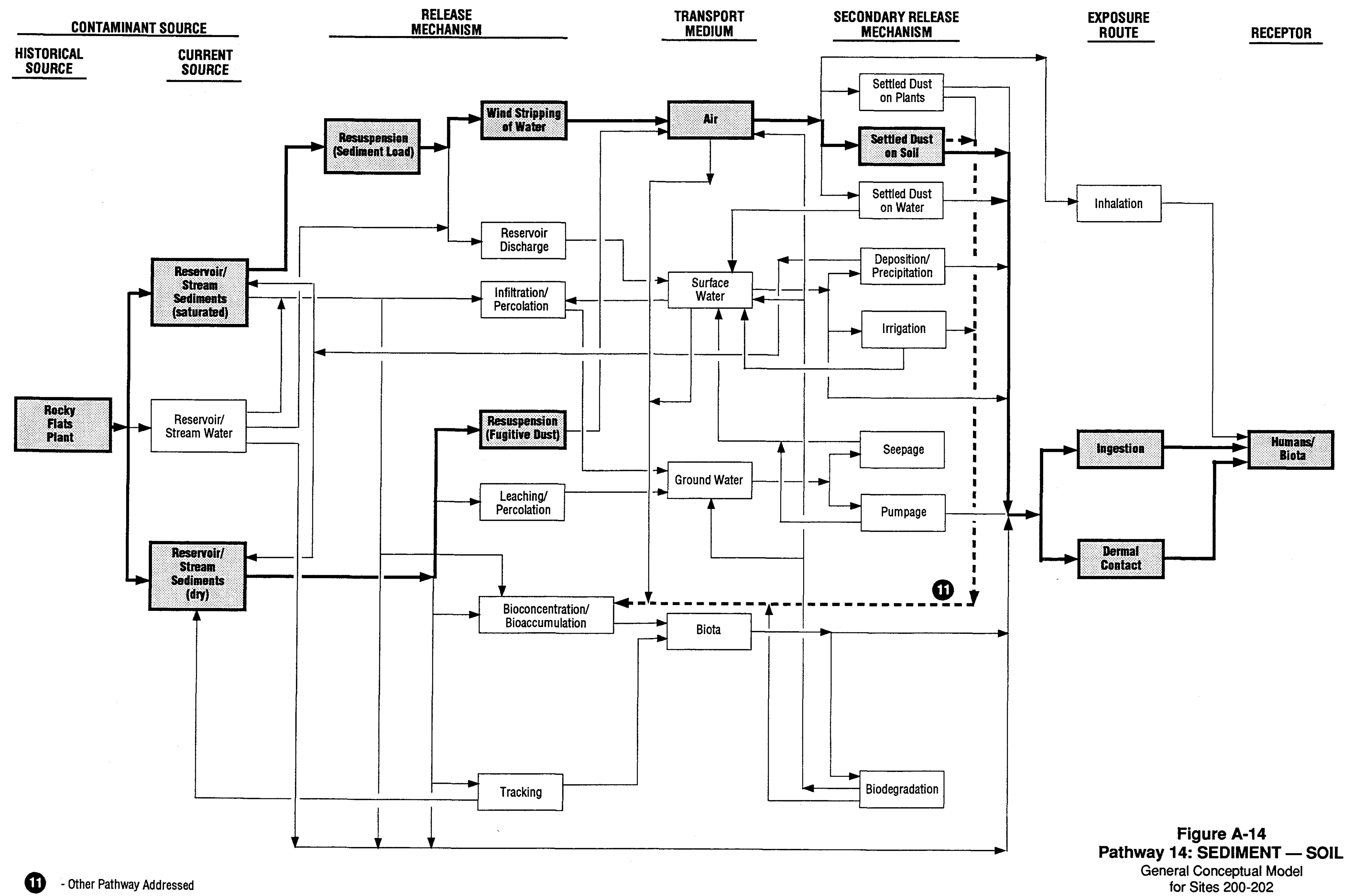


Figure A-14
Pathway 14: SEDIMENT — SOIL
General Conceptual Model
for Sites 200-202

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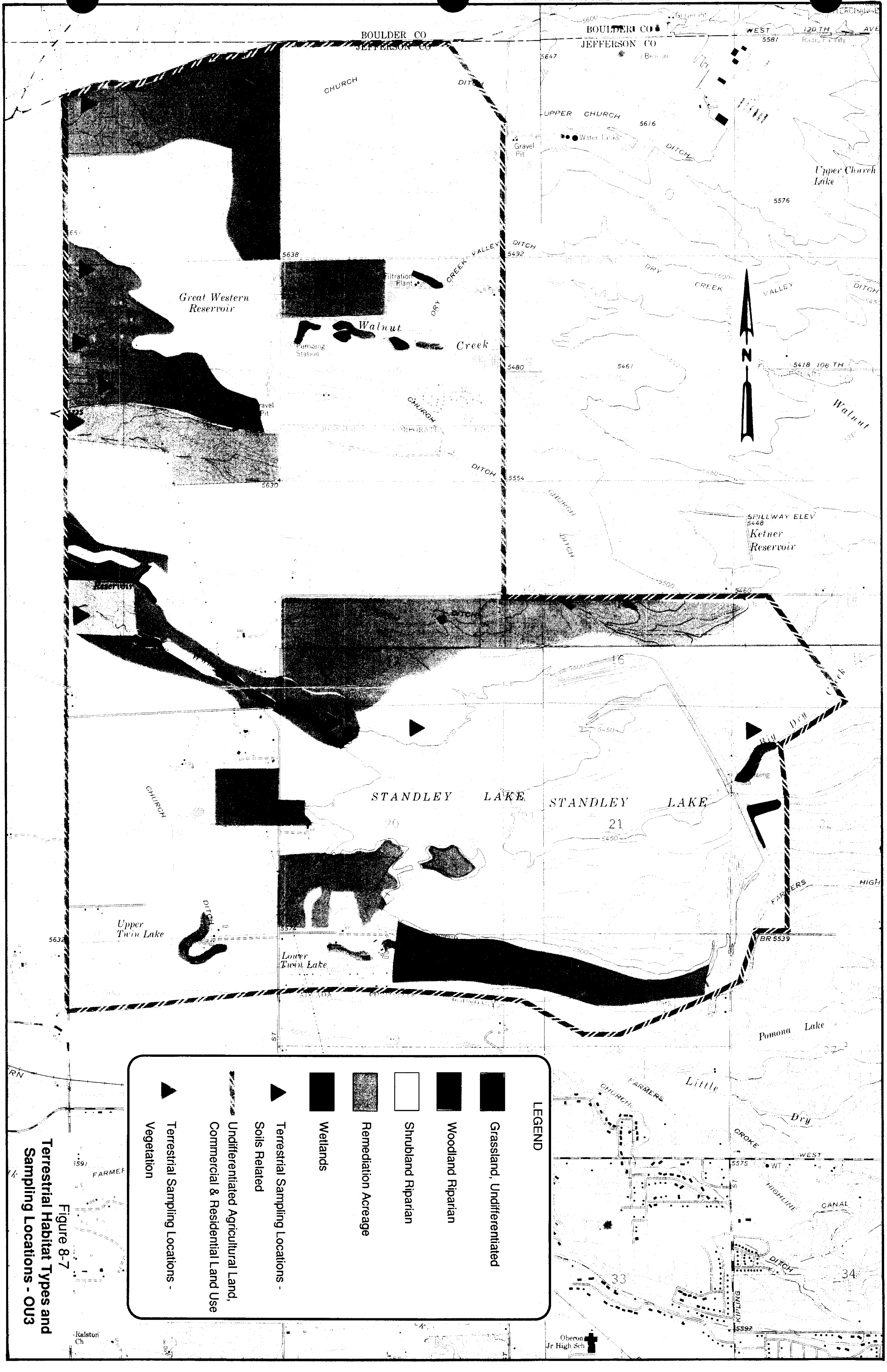

Figure 8-7
Terrestrial Habitat Types and Sampling Locations - OU3

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		APPROVED BY	CFW 11/22/91		

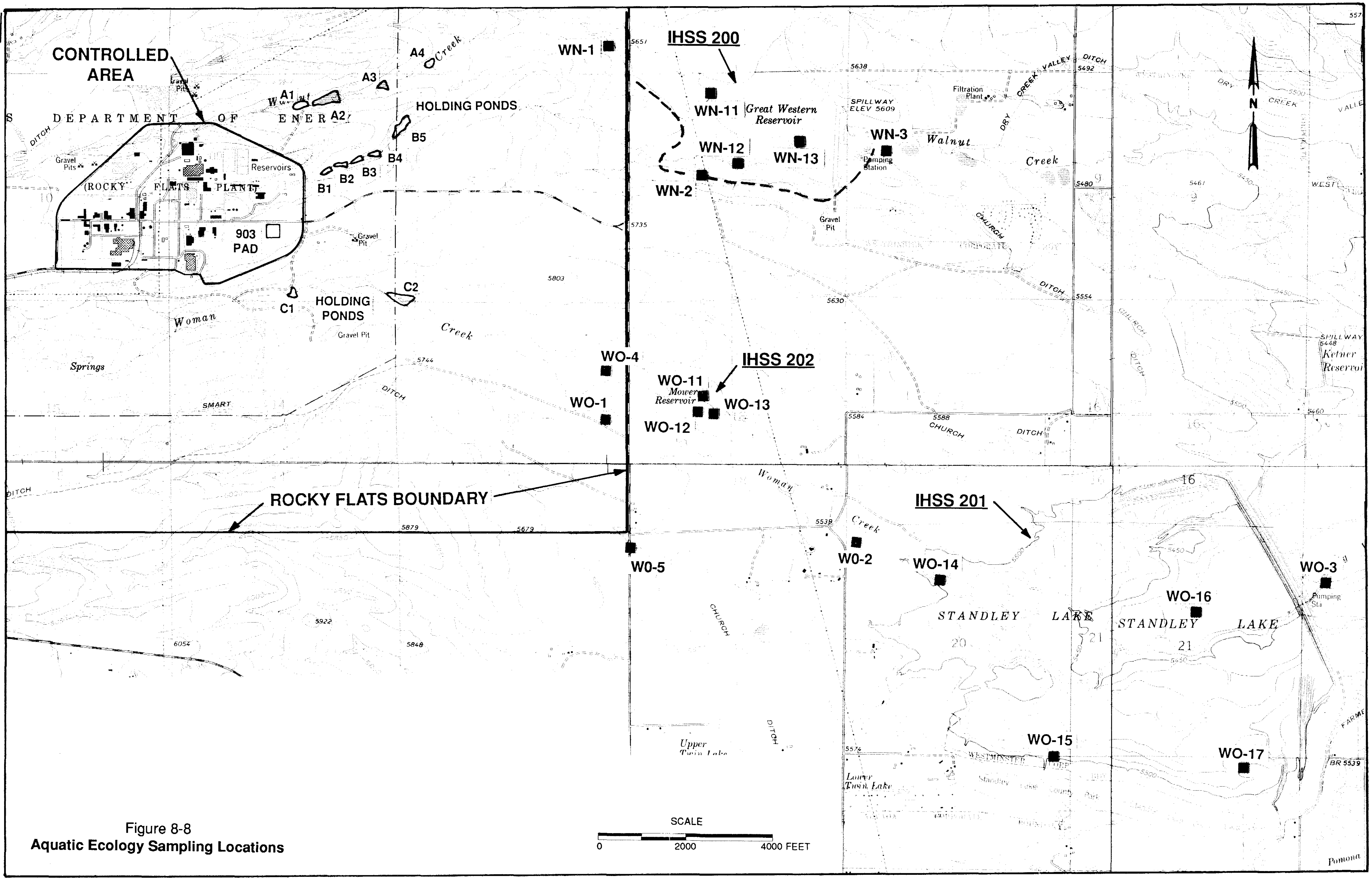

Figure 8-8
Aquatic Ecology Sampling Locations

DRAWN BY	Douville 11/04/9	CHECKED BY	PBS	11/21/91	DRAWING NUMBER	RF1
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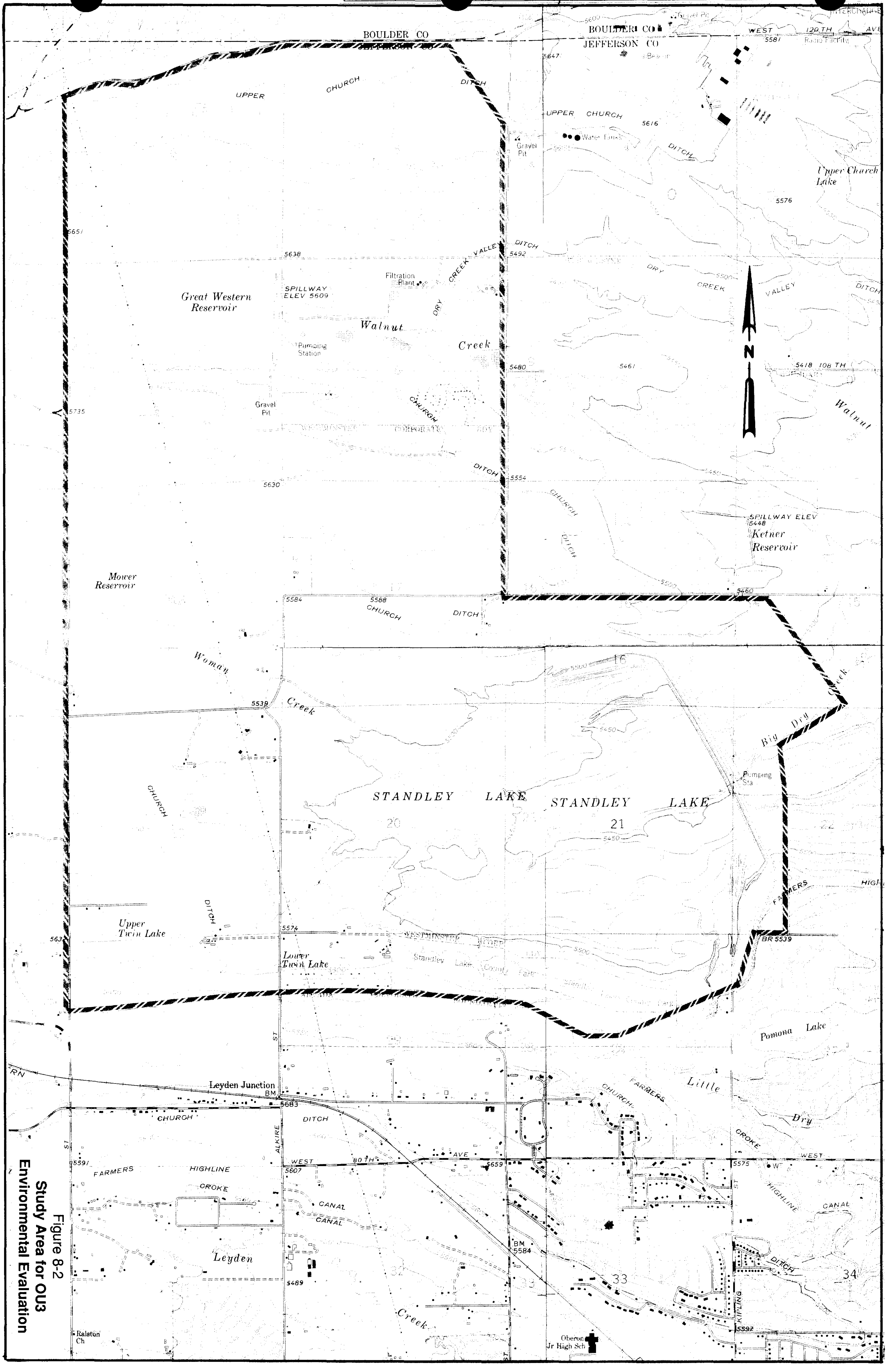

Figure 8-2
Study Area for OU3 Environmental Evaluation

DRAWN BY	Douville	CHECKED BY	PBsmith	2/18/92	DRAWING NUMBER	RF1067
	02/14/92	APPROVED BY	ALL	2/18/92		

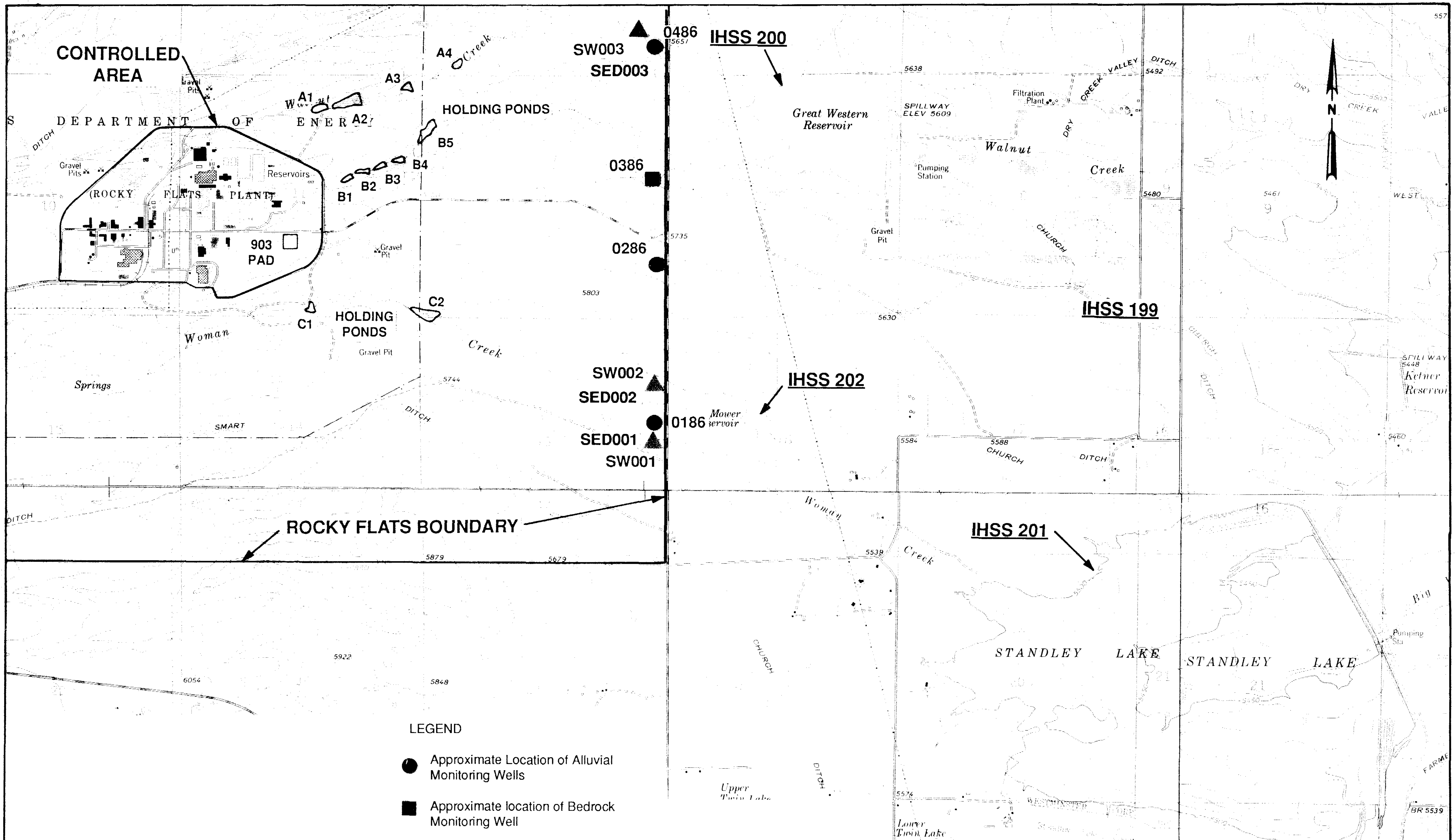

Figure 6-1
Approximate Location of Samples Reviewed for Selection of Chemical Analyses for OU3

DRAWN BY	Douville	CHECKED BY	PBSmith	2/18/92	DRAWING NUMBER	RF10
	02/14/92	APPROVED BY	ALL	2/19/92		

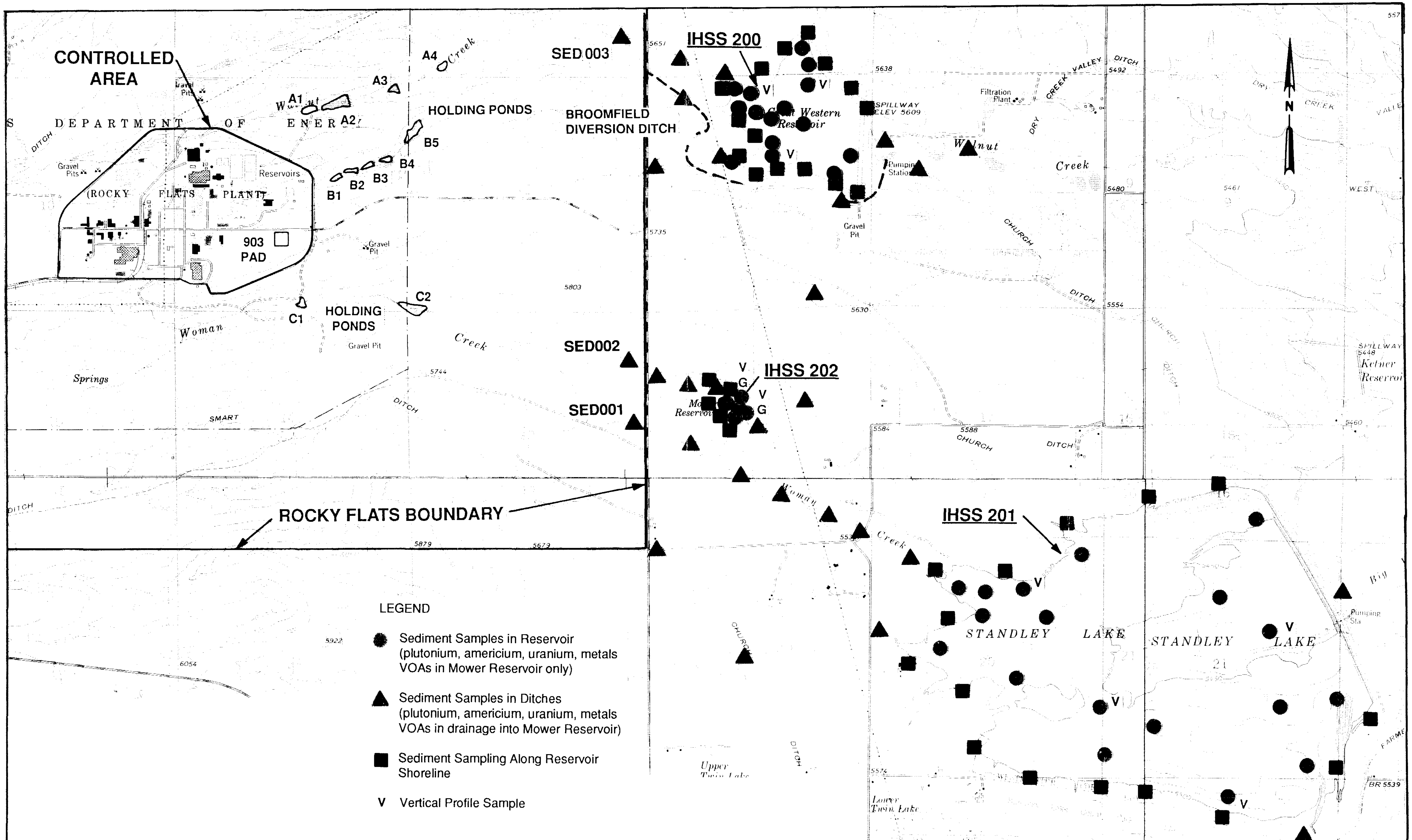

Figure 6-5
Approximate Location of Sediment Samples

DRAWN BY	Douville	CHECKED BY	PBSmith	2/14/92	DRAWING NUMBER	RF10
	02/14/92	APPROVED BY	HLL	2/19/92.		

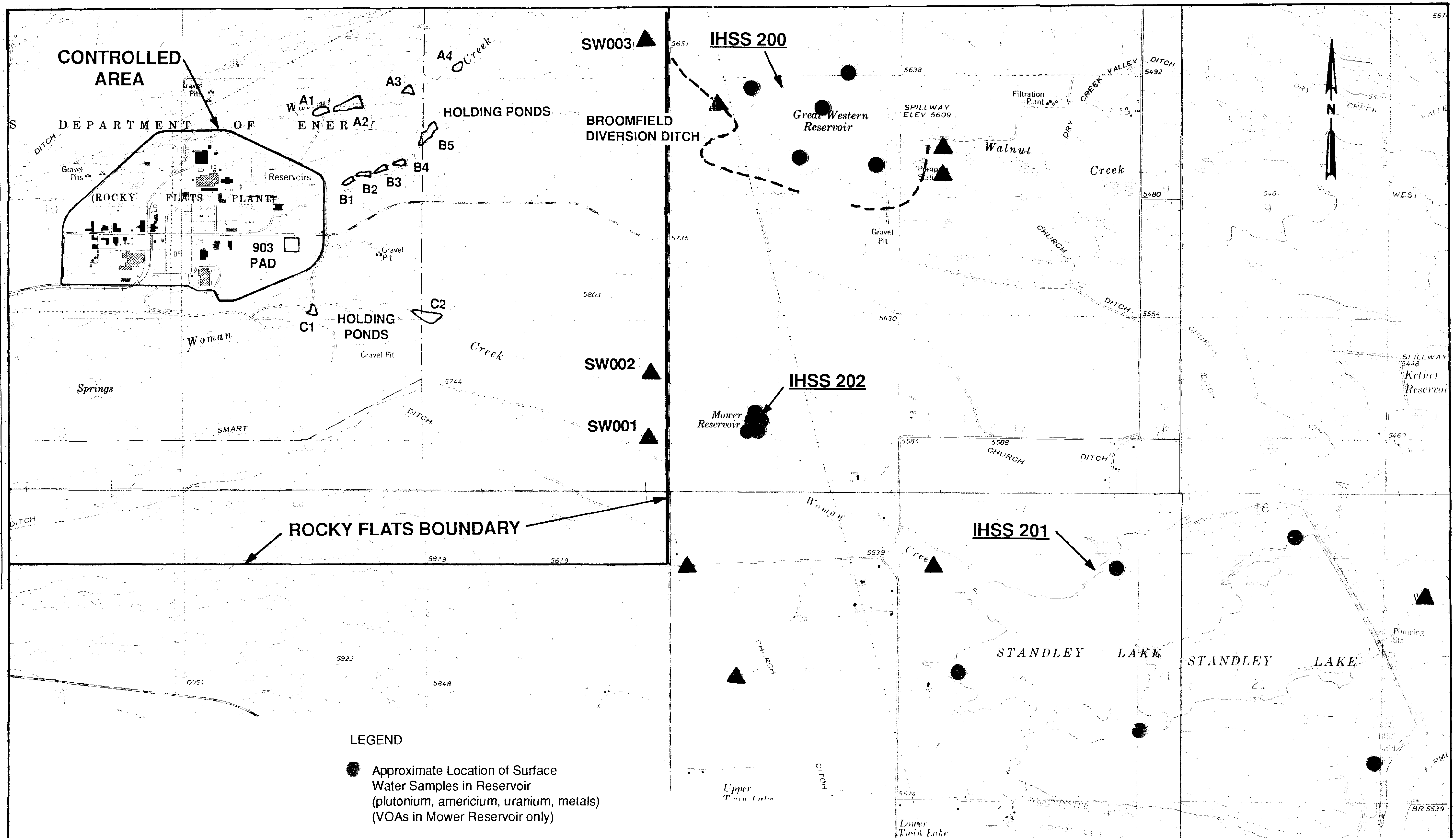

Figure 6-6
Approximate Location of Surface Water Sampling Locations

DRAWN BY	Douville 02/14/92	CHECKED BY	PB Smith	2/18/92	DRAWING NUMBER	RF1064
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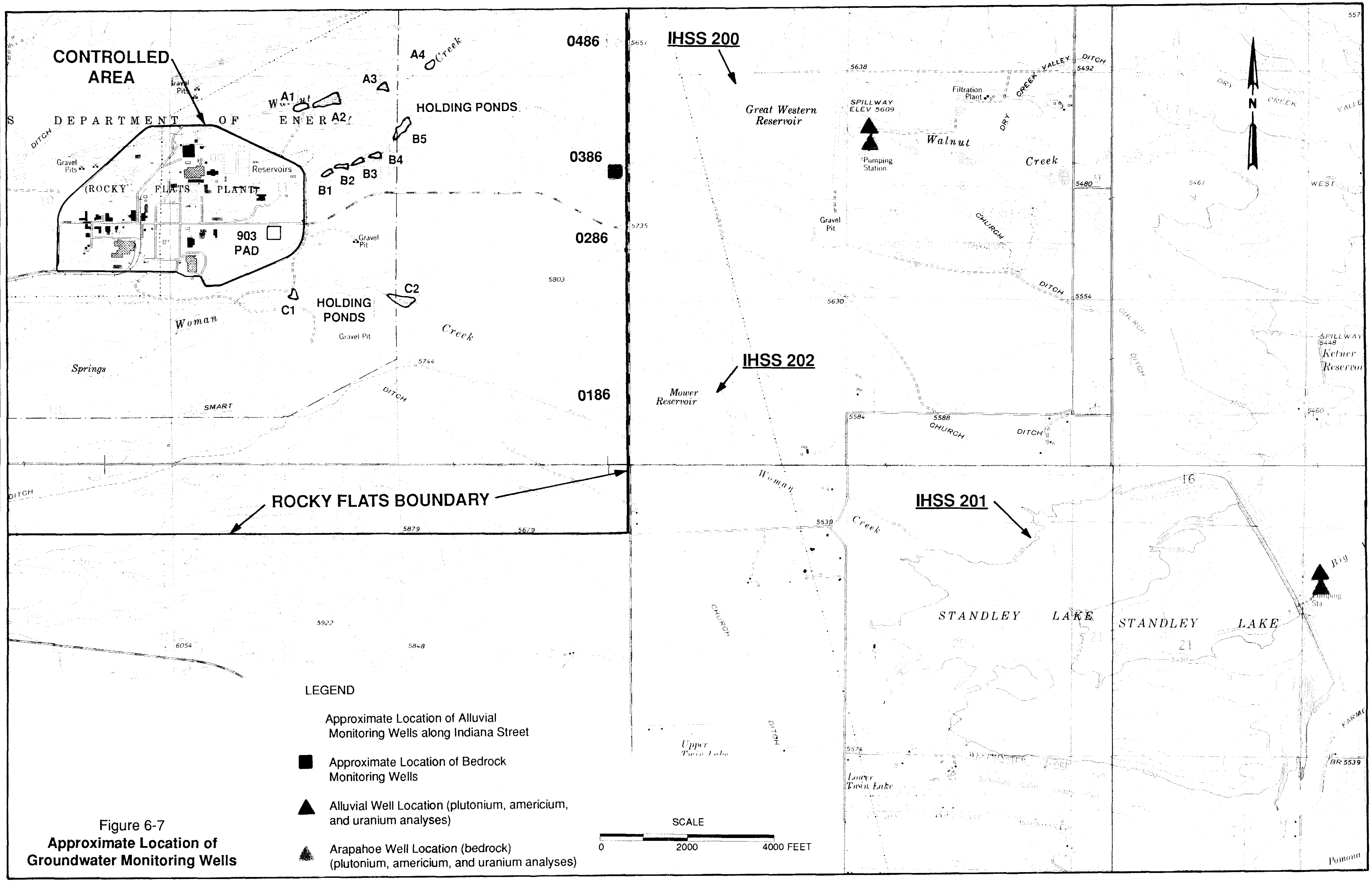

Figure 6-7
Approximate Location of Groundwater Monitoring Wells

DRAWN BY	Douville	CHECKED BY	PBSmith	2/18/92	DRAWING NUMBER	RF1063
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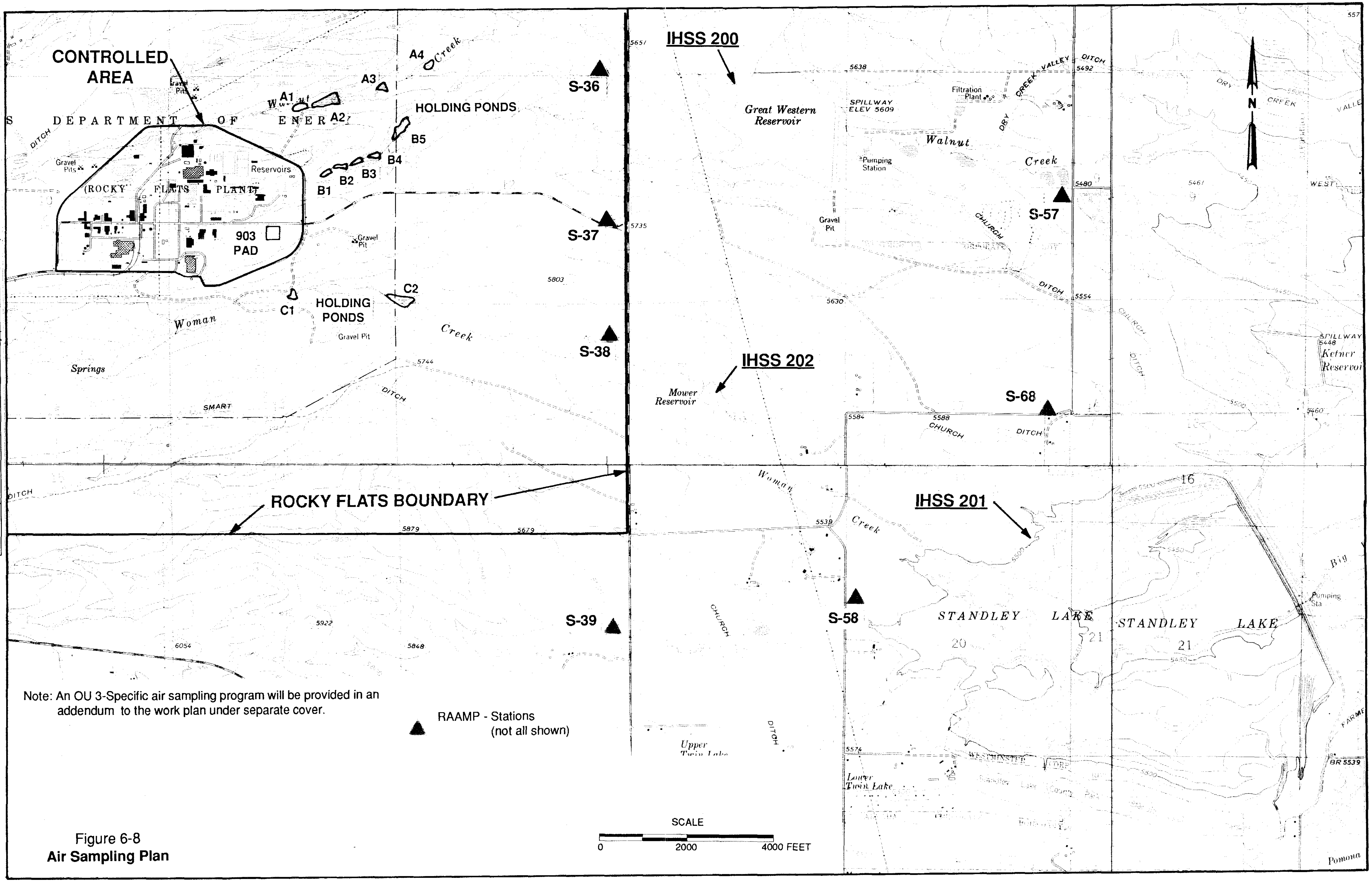

Figure 6-8
Air Sampling Plan

DRAWN BY	Douville 02/14/92	CHECKED BY	P. B Smith	2/17/92		DRAWING NUMBER	RF1062
		APPROVED BY	A. Lang	2/18/92			

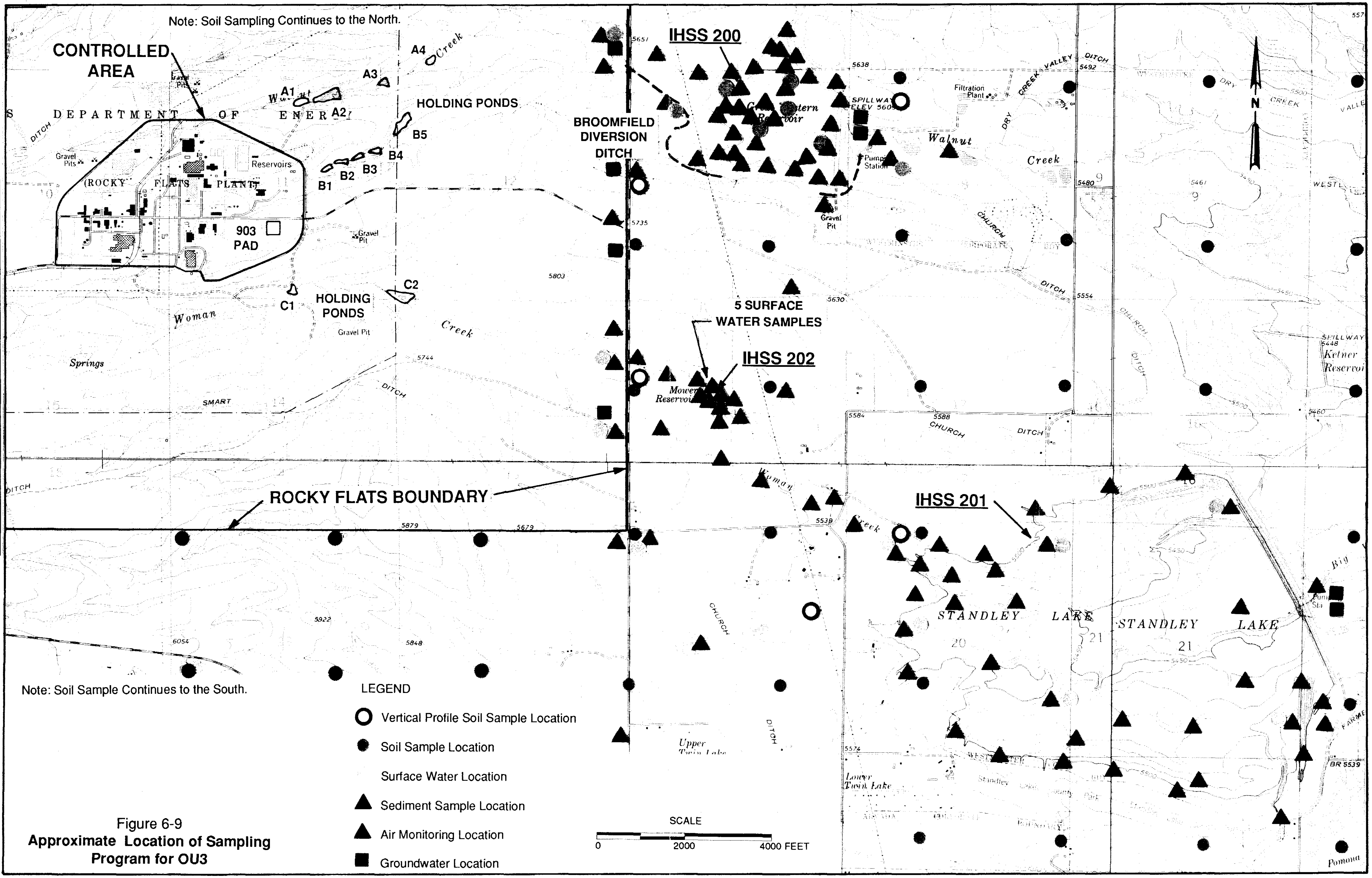

Figure 6-9
Approximate Location of Sampling Program for OU3